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## Stability of Immediately Placed and Delayed Implants Using Resonance Frequency Analysis (RFA). A Systematic Review

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## Stability of Immediately Placed and Delayed Implants Using Resonance Frequency Analysis (RFA). A Systematic Review

### Cover Page Footnote

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## **Stability of Immediately Placed and Delayed Implants Using Resonance Frequency Analysis (RFA). A Systematic Review**

### **Background**

Implant is a material or an object (alloplastic substance), partially or completely inserted into the body for therapeutic, diagnostic, prosthetic, or experimental purpose. Immediate implant placement refers to placing a dental implant in an extraction socket at the time of extraction, why wait when it can be done right away is a recent thought.<sup>1</sup>

Delayed implant placement is implant placement twelve weeks or more after extraction. It allows for elimination of infective processes, the achievement of maximum osteoblastic activity that helps the osseointegration process and complete wound covering that simplifies the placement of grafts or membranes.<sup>2</sup>

ISQ (Implant Stability Quotient) technology is a non-invasive diagnostic tool used to measure the stability of dental implants. It works by analyzing the implant's vibrational frequency and providing a numerical value.<sup>3</sup> ISQ technology uses a small, handheld device that is placed on the implant and provides real-time information on its stability. This information can be used to monitor the healing progress of the implant, assess the success of osseointegration and determine the appropriate timing for loading the implant.<sup>4</sup> ISQ technology provides a more objective measurement of implant stability compared to other methods, which rely on subjective assessments by the clinician. The scale ranges from 1 to 100, with higher values indicating greater stability. The acceptable stability range lies between 55 and 85 ISQ.<sup>5</sup>

### **Methods**

This SR was reported following the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist. (Figure 1)

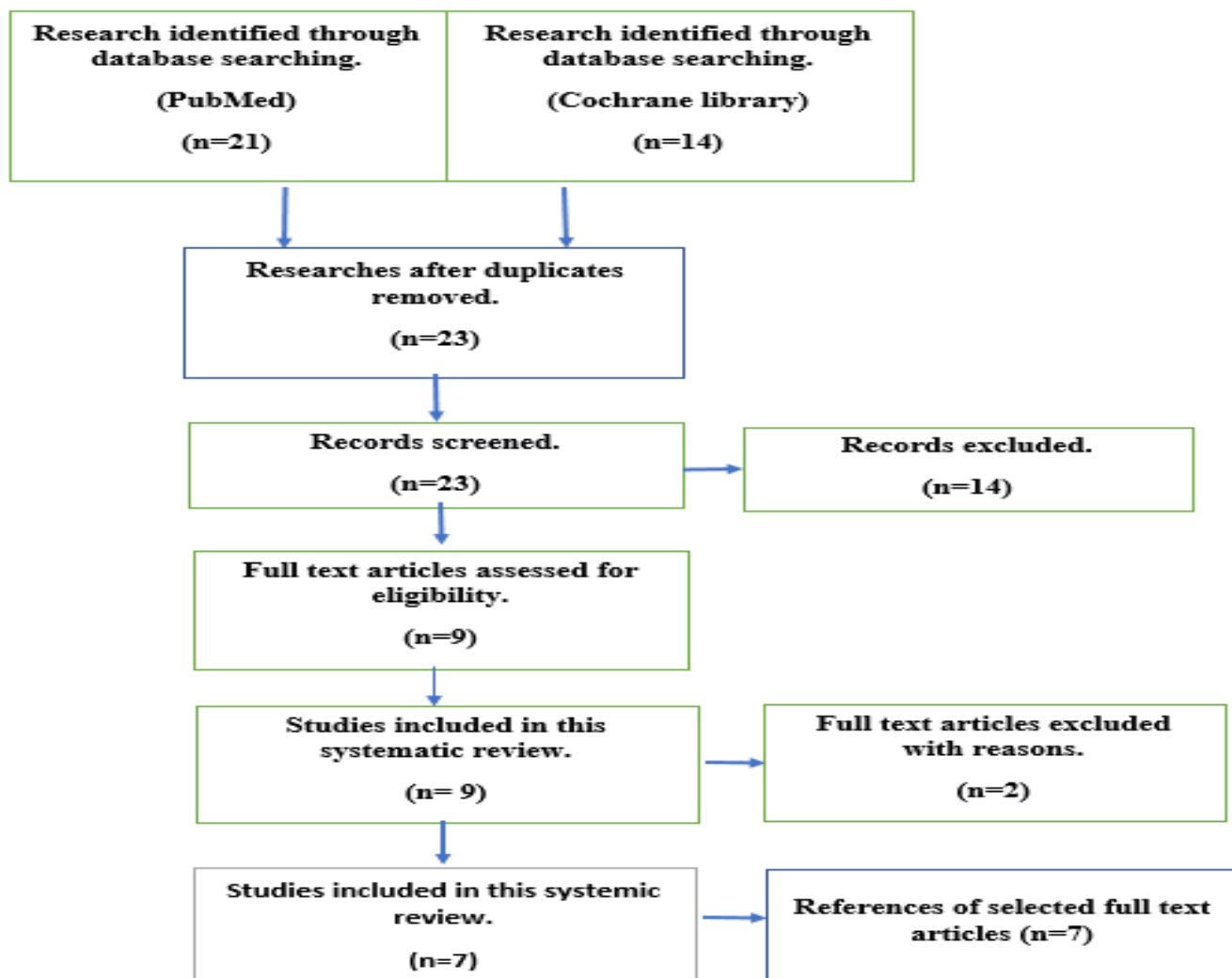
A PICO model (Problem, Intervention, Control and Outcome) was constructed.

**P: Implant stability**

**I: Immediate implant placement**

**C: Delayed implant placement**

**O: ISQ measurements**



**Figure 1:** (PRISMA) Flowchart

## Eligibility Criteria

Randomized clinical trials (RCTs) including Immediate implant placement (immediately after extraction), delayed implant placement and measurement data of ISQ at time of placement and at time of loading were included in this SR.

During primary screening (from title and abstract), we excluded one systematic review, 8 papers discussing implant loading, 3 papers discussing bone graft, one paper discussing orthodontic treatment and one paper studying implant surface treatment. After full text reading (secondary screening) we excluded 1 paper studying ISQ sensitivity and 1 paper discussing narrow implants in anterior region. (Figure 1).

## Information Sources

Search was performed in PubMed and Cochrane Library (2015 through March 2023) (Figures 2 and 3). Materials and Methods of the included studies are described in (table 1).

History and Search Details Download Delete

Search	Actions	Details	Query	Results	Time
#4	...	>	Search: (( <b>delayed dental implant placement</b> ) AND ( <b>immediate dental implant placement</b> )) AND (isq)	21	06:39:32
#3	...	>	Search: <b>isq</b>	1,056	06:35:20
#2	...	>	Search: <b>immediate dental implant placement</b>	3,385	06:34:44
#1	...	>	Search: <b>delayed dental implant placement</b>	726	06:33:49

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**Figure 2:** PubMed advanced Search

The screenshot shows the Cochrane Library search manager interface. At the top, there is a browser address bar with the URL [cochranelibrary.com/advanced-search/search-manager](https://cochranelibrary.com/advanced-search/search-manager). Below the address bar, there are navigation icons for Gmail, YouTube, and Maps. The main content area displays a list of search criteria, each with a plus (+) or minus (-) button, a search number (#1-#11), a search term, a search button (S), a MeSH tag, a Limits button, and a numerical result. The search terms are: #1: immediate dental implant placement (492 results, MeSH tag); #2: delayed dental implant placement (180 results); #3: ISQ (355 results); #4: #1 AND #2 AND #3 (14 results); #5: (ISQ) (358 results, with note: (Word variations have been searched)); #6: (immediate dental implant placement) (688 results, with note: (Word variations have been searched)); #7: (delayed dental implant placement) (198 results, with note: (Word variations have been searched)); #8: (immediate dental implant) (1273 results, with note: (Word variations have been searched)); #9: (delayed dental implant) (355 results, with note: (Word variations have been searched)); #10: #5 AND #6 AND #7 AND #8 AND #9 (14 results); #11: Type a search term or use the S or MeSH buttons to compose (N/A results).

Search #	Search Term	MeSH Tag	Limits
#1	immediate dental implant placement	MeSH	492
#2	delayed dental implant placement		180
#3	ISQ		355
#4	#1 AND #2 AND #3		14
#5	(ISQ)		358
(Word variations have been searched)			
#6	(immediate dental implant placement)		688
(Word variations have been searched)			
#7	(delayed dental implant placement)		198
(Word variations have been searched)			
#8	(immediate dental implant)		1273
(Word variations have been searched)			
#9	(delayed dental implant)		355
(Word variations have been searched)			
#10	#5 AND #6 AND #7 AND #8 AND #9		14
#11	Type a search term or use the S or MeSH buttons to compose		N/A

**Figure 3: Cochrane Library Search**

**Table 1:** Methodology table

Author	Year	Study design	Number of samples	Age	Implant Region	Maxilla	Mandible	ISQ	Immediate	Delayed
Granic et al. <sup>6</sup>	2015	RCT	60	>20	Premolar	Yes	No	Yes	30	30
Rowan et. al. <sup>7</sup>	2015	RCT	85	19-93	N/A	No	No	Yes	41	96
Ning et. al. <sup>8</sup>	2019	RCT	86	N/A	Anterior premolar	Yes	Yes	Yes	46	40
Malchiodi et al. <sup>9</sup>	2016	RCT	40	54 median	Premolar/ Molar	No	No	Yes	20	20
Huang et al. <sup>10</sup>	2016	RCT	177	19-100	N/A	Yes	Yes	Yes	71	106
Tallarico et al. <sup>11</sup>	2017	RCT	24	N/A	Molar	Yes	Yes	Yes	12	12
Huang et al. <sup>12</sup>	2017	RCT	336	19-100	N/A	Yes	Yes	Yes	172	385

**Risk of Bias**

All studies were assessed for risk of bias.

**Table 2:** Risk of Bias table.

Author	Selection	Performance	Detection	Attrition
Granic et al. <sup>6</sup>	N/A	No	No	No
Rowan et. al. <sup>7</sup>	No	No	No	N/A
Ning et. al. <sup>8</sup>	No	No	No	No
Malchiodi et al. <sup>9</sup>	No	No	No	No
Huang et al. <sup>10</sup>	No	No	No	Yes
Tallarico et al. <sup>11</sup>	No	No	No	No
Huang et al. <sup>12</sup>	No	No	No	Yes

## Results

**Table 3:** The results of the selected 7 studies.

Author	Immediate dental implant	Delayed dental implant
<b>Granic et al.<sup>6</sup></b>	63.5 ± 6.2, 70.3 ± 5.1, and 73.8 ± 4.7 at baseline, 6 weeks, and 12 weeks post-implantation, respectively.	62.9 ± 5.9, 69.2 ± 4.8, and 73.3 ± 4.6 at baseline, 6 weeks, and 12 weeks post-implantation, respectively.
<b>Rowan et al.<sup>7</sup></b>	Mean ISQ values in the 2 immediate implant groups exceeded the ISQ threshold of 65. Immediately placed implants in the 2- to 3-month and 4- to 6-month groups had average ISQ values of 65.60 and 68.65, respectively. Follow up had averages of 73.88 and 70.14.	Averages of 76.73 (2- to 3-month group) and 71.23 (4- to 6-month group). Follow up 79.58 (2- to 3-month group) and 77.31 (4- to 6-month group)
<b>Ning et al.<sup>8</sup></b>	Results were above ISQ threshold value of 65, which suggests no significant difference between immediate and delayed implant stability.	
<b>Malchiodi et al.<sup>9</sup></b>	Results were above ISQ threshold value of 65, which suggests no significant difference between immediate and delayed implant stability.	
<b>Huang et al.<sup>10</sup></b>	Immediately after implantation 73.68±6.50 And right before loading 77±4.30	Immediately after implantation 75.82±5.49 And right before loading 77.63±4.07
<b>Tallarico et al.<sup>11</sup></b>	6 months after implant placement, mean ISQ value was 78.8 ± 2.8 1 year after loading, mean PES was 10.6 ± 1.8 [range: 8 to13]	6 months after implant placement, mean ISQ value was 79.9 ± 3.6 1 year after loading, mean PES was 12.2 ± 1.2 [range: 11 to 14]



**Huang et al.<sup>12</sup>**

Constant and Influencing factors (X)	Unstand. Coef. $\beta \pm SE$		
	Group 1 Surgeon no. 1 SiCace	Group 2 Surgeon no. 2 SiCace	Group 3 Surgeon no. 2 Osstem
Constant	57.263±4.226***	57.444±4.470***	62.730±3.556***
X1	1.317±.622*	—	—
X2	—	0.143±0.051**	—
X3	1.471±.652*	—	—
X4	1.836±.664**	—	—
X5 <sup>§</sup>	-4.990±1.135***	-4.006±1.638*	-4.117±1.255***
X6	1.669±.754*	—	—
X7 <sup>§</sup>	—	—	—
X8	2.961±.657***	—	4.948±1.234***
X9	0.131±.025***	—	0.277±0.069***
X10 (1, 2, 3)	—	7.590±3.119*	—

Unstand. Coef.: Unstandardized Coefficients. (X1): Sex; (X2): Age; (X3): Maxillary/mandibular location; (X4): Immediate/delayed implantation; (X5): the need for Bone grafting; (X6): Implant diameter; (X7): Implant length; (X8): I/II-stage implantation; (X9): Insertion torque; (X10) Bone type; and (X11): T1-time interval.

<sup>§</sup> indicates significant general influencing factors.

<sup>§</sup> indicates insignificant general influencing factors.

\*: 0.01 < P ≤ 0.05

\*\* : 0.001 < P ≤ 0.01

\*\*\*: P ≤ 0.001.

Constant and Influencing factors (X)	Unstand. Coef. $\beta \pm SE$		
	Group 1 Surgeon no. 1 SiCace	Group 2 Surgeon no. 2 SiCace	Group 3 Surgeon no. 2 Osstem
Constant	56.988±3.043***	73.198±7.275***	50.608±4.765***
X1 <sup>§</sup>	—	—	—
X2 <sup>§</sup>	—	—	—
X3	—	—	2.646±0.752***
X4	—	—	4.628±1.002***
X5	—	-2.665±1.111*	—
X6 <sup>§</sup>	4.080±0.698***	3.454±1.222**	4.197±1.194***
X7 <sup>§</sup>	—	—	—
X8 <sup>§</sup>	—	—	—
X9	0.048±0.698*	—	—
X10 <sup>§</sup>	—	—	—
X11	0.014±0.005**	—	—

Unstand. Coef.: Unstandardized Coefficients. (X1): Sex; (X2): Age; (X3): Maxillary/mandibular location; (X4): Immediate/delayed implantation; (X5): the need of Bone grafting; (X6): Implant diameter; (X7): Implant length; (X8): I/II-stage implantation; (X9): Insertion torque; (X10) Bone type; and (X11): T1-time interval.

<sup>§</sup> indicates significant general influencing factors.

<sup>§</sup> indicates insignificant general influencing factors.

\*: 0.01 < P ≤ 0.05

\*\* : 0.001 < P ≤ 0.01

\*\*\*: P ≤ 0.001.

## Discussion

Immediate implant placement has become increasingly popular due to its advantages; shorter treatment time and preservation of alveolar bone. However, concerns have been raised regarding the stability of immediately placed implants. These studies provide evidence that immediate implants can achieve comparable or even higher stability than delayed implants when assessed using RFA. It is worth noting that there were discrepancies between the studies in terms of which technique resulted in higher stability values over time.

Granić et al.<sup>6</sup> found that immediate placement resulted in higher stability values over time, Rowan M et al.<sup>7</sup> found a trend towards immediate placement group due to reaching ISQ value threshold above 65.

Huang et al.<sup>8</sup> Compared the rate of success, stability of the implants, probing depth, aesthetics, marginal bone level and satisfaction after follow-up, records were taken 3 months after implant placement and at the time of permanent restoration, with a non-invasive extraction, results suggested that delayed and immediate implant placement both had good results in means of stability, however, immediate implantation showed better satisfaction, concerning aesthetics and clinical application.

Malchiodi et al.<sup>9</sup> investigated the performance of implants inserted either in fresh extraction sockets or after 12-week healing period. Implant success and survival rate, when assessed at the 12- month follow-up, were 100% in both groups.

Huang et al.<sup>10</sup> suggested that immediate implant placement had several advantages; reduced surgical trauma, short time of treatment and better conservation of soft tissue and bone. They also found that immediate implants had long term success rate and better esthetics when compared to delayed implant placement. However, they stated that immediate implant technique is considered sensitive

concerning gaining primary stability which if not achieved, high rate of implant failure will occur.

Tallarico et al.<sup>11</sup> suggested that both immediate and delayed implants achieved good results in 1-year follow-up period concerning implant stability, while waiting after extraction for 4 months and using socket preservation technique caused less Cristal bone loss & resulted in better aesthetics.

Huang et al.<sup>12</sup> findings suggested that Immediate/delayed implantation Had no significant influence on the ISQ values and implant stability. Also other factors like Sex, Age, Maxillary/mandibular location, Implant diameter, Insertion torque, Bone type and time interval, had no significant influence on the ISQ values and implant stability. While bone grafting was considered the only influencing factor on ISQ values and implant stability and Implant length was considered insignificant influencing factor.

After assessment of all previous findings both immediate and delayed implant placement revealed stable implants results. However, clinicians should consider the specific needs of each patient when deciding which technique to use. Immediate placement may be preferable for patients who require shorter treatment times or have concerns about bone preservation, while delayed placement may be preferable for patients who require higher stability values over time.

### **Limitations of the Review Process**

This SR included only peer-reviewed studies published in English, but this did not affect the study conclusions. And searched in only two databases (PubMed and Cochrane Library).

## **Conclusion**

Implant stability can be achieved with both immediate and delayed implant placement techniques. Immediate placement allows shorter treatment time, preservation of alveolar bone and better esthetic effect.

Further research is needed to explore other factors (implant design or surgical technique) that may affect implant stability over time, and to fully understand the long-term outcomes of immediate and delayed implant placement.

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