**Introduction**

The life expectancy of humans has increased in the last few decades due to the improved and continuous progress in the medical field. The loss of teeth due to old age and its replacement is seen as a natural phenomenon. The complete loss of teeth during the fourth and fifth decades of life due to various lifestyle habits and diseases is more common today. The increase in the level of education and improved patient awareness has led to an increase in patients demanding higher quality treatment options. Age-related tooth loss, anatomic condition of edentulous ridges, psychological needs, decreased performance of removable prostheses, and predictable long-term results of implant-supported prostheses have increased the demand for implant-supported rehabilitation of teeth.

Traditional treatment plans typically called for a large number of implants placed in fairly vertical positions throughout the entire arch.1 However, the rehabilitation of edentulous jaws with implants is often complicated by poor bone quality, especially in the posterior region, and reduced bone volume due to a long-term edentulous state.2 Alveolar bone resorption and pneumatization of the maxillary sinus reduce, in many cases, the available amount of bone in both width and height for the placement of dental implants in the edentulous posterior maxilla.3 In the mandible, the inferior alveolar nerve and associated structures may provide minimal bone for implant anchorage or prevent the placement of implants distal to the mental foramina altogether.3 Bone grafting procedures to increase the bone volume available for implant placement is a viable treatment option but they often require demanding surgical procedures and can lead to complications, morbidity, and high costs. Therefore, patient compliance is often poor.2

If posterior implants could not be placed and to compensate for these biologic limitations, a lengthy cantilever distal to the terminal implant was typically needed to provide patients with adequate posterior dentitions; however, extensive posterior cantilevers are biomechanically unfavorable due to increased occlusal forces.1

To overcome such limitations, different therapeutic alternatives have been proposed, such as long distal cantilever (Shackleton et al. 1994),4,5 short implants (Goené et al.;6 Renouard and Nisand;7 Maló et al.;8) or implants placed in specific anatomical areas like, for the maxilla, the pterygoid region, the tuberosity of the zygoma (Khayat and Nader;9 Venturelli;10 Balshi et al.;11 Brånemark et al.;12 Galán Gil et al.;13 Aparicio et al.;14 Maló et al.15). Any of these procedures requires considerable surgical expertise and has its advantages,
Rehabilitation of Edentulous Arches with Fixed Prosthesis Supported by Tilted Implants

In recent years, several clinical studies have reported that placement of implants at an angulation is a feasible option (Krekmanov;16 Krekmanov et al.;17 Aparicio et al.;18 Malé et al.19,20 Calandrelli and Tomatis;21 Capelli et al.;22 Agliardi et al.23,24). The introduction of tilted implants has provided a significant alternative for the restoration of maxillary and mandibular posterior segments without bone grafting.1 Tilted implants provide several surgical and prosthetic advantages, like the possibility of placing long implants with an improvement of bone anchorage, the reduction of the need for bone grafting, the avoidance of long cantilevers, and the possibility of increasing the distance between anterior and posterior abutments, with an improvement of the load distribution.2

The All-on-4® treatment concept was introduced by Nobel Biocare AB, Göteborg, Sweden. This protocol using only four implants has produced good short-term outcomes, with a survival rate of 98.2% and marginal bone level of 0.6 mm at 6-month follow-up. Since this first report, several other authors have reported good short- and medium-term outcomes for patients undergoing this treatment. Moreover, recent systematic reviews have confirmed these results for maxilla and mandible rehabilitation.24

The All-on-6 treatment protocol is used to minimize the length of the cantilever. It is a deviation from the All-on-4 treatment modality (Tables 1 to 4). The different treatment modalities provide various advantages to the clinicians as well as to the patients. But they also come with a variety of disadvantages too. The failure rate of such treatment modalities even though is less cannot be ignored. For this treatment option to be widely advocated and used successfully, one has to sort out the factors which favor and those which are unfavorable to this treatment option. The factors which contribute to the failure of such cases cannot be assessed from the reports of a handful of patients treated by a single clinician. Therefore, one needs to extensively study and carefully assess a considerable number of cases treated.

Thus, this review aims to seek evidence and to find the factors which are favorable and unfavorable for the use of a minimal number of implants for the complete arch rehabilitation of a patient.

Materials and Methods
An electronic search was carried out in PubMed and Medline. The keywords used for the search were “dental implant”, “tilted implant”, “axial implant”, “edentulous patient”, “edentulous maxilla”, and “edentulous mandible”, “implant-supported dental prosthesis”, “immediate loading and immediate placement”. They were used alone or in combination.

Inclusion Criteria
- The articles from 2005 to 2016 were included in the study.
- The articles selected were limited to in vivo studies involving human subjects with a minimum of 10 patients treated.
- Studies with a minimum of 4 implants and a maximum of 10 implants placed on a single arch of which at least two are tilted implants were considered.
- Articles with a minimum of 1-year follow-up and loss of study participants <10% were included.
- Use of tilted implants.
- The survival rate of tilted and upright implants should be indicated and calculable from the data provided.

Exclusion Criteria
Multiple publications with the same pool of patients, single case reports, studies with missing data, and studies in languages other than English were excluded. Publications that did not meet the above inclusion criteria and those that were not dealing with original clinical cases (reviews and technical reports) were also excluded.

Studies dealing with orthodontic implants, mini-implants, partial rehabilitation, and removable prosthesis were excluded too.

Thirty-three articles were selected for the final review which were all clinical studies with human participants and had a follow-up period of 1 year or more. In all the studies included in this review, a minimum of four implants were placed in each arch and one implant placed in each arch was angulated. The restoration of an edentulous maxilla or mandible or both with implant retained fixed prosthesis is the best treatment option available currently with long-term patient satisfaction and comfort compared to other methods of teeth replacement.

Outcomes
After analyzing the selected articles the following outcomes were thoroughly analyzed.

- Type of study.
- Sample size.
- Number of implants placed.
- Number of implants placed in each arch.
- Angulation of the implant placed.
- The use of surgical guides for implant placement.
- The time of implant placement.
- The loading protocol was followed.
- The length of the cantilever.
- Type of provisional restoration/prosthesis.
- Type of opposing dentition.
- Follow-up interval.
- Follow-up period.
- Bone loss.
- Patient satisfaction.

Results
A total of 75 articles were obtained through the initial screening process. Out of which 28 articles were discarded as they did not fulfill the inclusion criteria. A total of 47 articles were identified as potentially eligible articles through screening by titles and abstracts. The full-text articles were obtained and thoroughly evaluated. As a result, 33 articles fulfilled the inclusion criteria and were included in the systematic review.

The review analyzed 15 criteria from each article, which include the type of study, sample size, number of implants used, number of implants placed per arch, the angulation of the implants placed, the use of surgical guides, the surgical protocol followed, time of placement of a provisional restoration, the length and presence of cantilever, type of opposing dentition, follow-up interval, follow-up period, bone loss at the implant site, patient satisfaction and the implant failures.

Of the 33 articles analyzed, 21 (63.63%) articles reported failure of implants. A total of 161 (1.56%) implants failed out of the 10,300 implants placed. In the 161 failed implants, 63 (39.13%) were axially placed implants and 63 (39.13%) were implants placed...
Table 1: Master chart

| S. no. | Authors/journal | Type of study | Sample size | No. of implants | Angulation of implants (°) | Time of implant placement | Type of provisional prosthesis | Type of opposing dentition | Follow-up interval | Follow-up period | Bone loss | Patient satisfaction |
|--------|-----------------|---------------|-------------|----------------|---------------------------|-------------------------|-------------------------------|----------------------------|------------------|-----------------|----------|----------------------|
| 1      | Agliardi et al. COIR 2010 | Prospective study | 173 | 692 | 4 | 30–45 | Nil | Immediate | Immedi- ate loading | Acrylic prosthesis | Mandible: Removable partial denture-50 Fixed prosthesis on natural teeth-15 Natural teeth and fixed prosthesis on natural teeth-12 Implant-supported bridge-9 Natural teeth and two implant-supported bridge-4 Maxilla: Implant-supported fixed prosthesis-25 Removable prosthesis-22 Natural teeth-9 Fixed prosthesis on natural teeth-5 | Once a week | For 1 month | Maxilla: 0.9 ± 0.7 | NA |
| 2      | Weinstein et al. | Prospective study | 20 | 80 | 4 | 30 | Nil | Immediate | Immediate loading | Acrylic prosthesis | Removable prosthesis-11 | 6 months | For 2 years | Axial: Esthetic: excellent and very good by 66.70% of patients | Contd... |
| S. no. | Authors/ journal | Type of study          | Sample size | No. of implants | No. of implants in each arch | Angulation of implants (°) | Time of implant placement | Loading protocol | Length of cantilever | Type of provisional prosthesis | Type of opposing dentition | Follow-up interval | Follow-up period | Bone loss | Patient satisfaction |
|-------|------------------|-----------------------|-------------|-----------------|-----------------------------|---------------------------|---------------------------|-----------------|-------------------|-----------------------------|--------------------------|----------------|----------------|-----------|-------------------|
| 3     | Malo et al.      | Retrospective study   | 32          | 128             | 4                           | 30                        | Used                      | Immediate       | NA                | Natural teeth and fixed prosthesis on natural teeth-4 | Implant-supported prosthesis-5 | 1 year         | For 5 years     | 0.6 ± 0.3 | Tilted: 0.7 ± 0.4 |
| 4     | Malo et al.      | Clinical report       | 242         | 968             | 4                           | 45                        | Used                      | Immediate       | NA                | All acrylic prosthesis               | All acrylic prosthesis-15 | 6 months       | 1 year         | 0.9 mm    | NA                |

Contd...
| S. no. | Authors/ journal | Type of study | Sample size | No. of implants | No. of implants in each arch | Angulation of implants (°) | Time of implant placement | Loading protocol | Length of cantilever | Type of provisional prosthesis | Type of opposing dentition | Follow-up interval | Follow-up period | Bone loss | Patient satisfaction |
|-------|------------------|---------------|-------------|----------------|-----------------------------|--------------------------|-------------------------|----------------|-------------------|--------------------------|--------------------------|----------------|----------------|-----------|------------------|
| 5     | Capelli et al.   | Clinical study | 65          | 342            | Max-6                       | Max-30–35                | Nil                     | Immediate       | NA                | Acrylic resins teeth          | Immediate loading          | 3 months       | 5 years        | Maxilla: Satisfied with the esthetics, phonetics, and function |
|       |                   |               |             |                |                             |                          |                         |                 |                   |                          |                          |                |               |           |                  |
|       |                   |               |             |                |                             |                          |                         |                 |                   |                          |                          |                |               |           |                  |
| 6     | Krenn-mair et al. | Prospective study | 41          | 164            | Maxilla-160                 | Angulation-40            | Nil                     | Conventional    | Group I: 15.7 ± 2.1 | Acrylic veneered teeth | Natural teeth-3          | 1 year         | 3 years        | At 1 year: NA | At 2 years: 1.26 ± 0.42 |
|       | Clinical Implant Dentistry and Related Research 2016 | | | | Mandible-4 | | | Group II: 13.7 ± 2.1 | | | | |

Contd…
| S. no. | Authors/ journal | Type of study | Sample size | No. of implants | Angulation of implants (°) | No. of implants in each arch | Surgical guide/ freehand implant placement | Time of implant placement | Loading protocol | Length of cantilever | Type of provisional prosthesis | Type of opposing dentition | Follow-up interval | Follow-up period | Bone loss | Patient satisfaction |
|-------|------------------|---------------|-------------|-----------------|---------------------------|-----------------------------|----------------------------------|---------------------------|-----------------|-------------------|---------------------------|--------------------------|-------------------------|-------------------|----------|---------------------|
| 7     | Lopes et al.     | Retrospective study | 111         | 532             | Angulation-45            | 4 per arch                   | Surgical template            | Conventional               | Immediately loading | NA                | Acrylic resin          | NA                       | 1 year                  | 7 years          | Overall 1.3 mm   | NA                   |
|       |                  |               |             |                 |                           |                             |                                  |                          |                 |                   |                           |                          |                         |                   | Tilted: 1.27 mm | NA                   |
|       |                  |               |             |                 |                           |                             |                                  |                          |                 |                   |                           |                          |                         |                   | Axial: 1.34 mm   | NA                   |
| 8     | Maló et al.      | Retrospective pilot study | 46          | 189             | Maxilla-45               | 4 per arch                   | Surgical guide               | Immediate and delayed       | Immediate loading         | NA                | All acrylic          | Implant-supported prosthesis-27 | 10 days                 | 1 year                 | 1.2 ± 0.7       | NA                   |
|       |                  |               |             |                 |                           |                             |                                  |                          |                 |                   |                           |                          |                         |                   |                       | Comb. 5            |
|       |                  |               |             |                 |                           |                             |                                  |                          |                 |                   |                           |                          |                         |                   |                       | RPD-1               |
| S. no. | Authors/journal | Type of study | Sample size | No. of implants | No. of implants in each arch | Angulation of implants (°) | Surgical guide/freehand implant placement | Time of implant placement | Loading protocol | Length of cantilever | Type of provisional prosthesis | Type of opposition dentition | Follow-up interval | Follow-up period | Bone loss | Patient satisfaction |
|-------|----------------|---------------|-------------|-----------------|----------------------------|----------------------------|-------------------------------|---------------------------|----------------|------------------|---------------------------------|---------------------------|----------------|----------------|----------|---------------------|
| 9     | Sannino et al. | Retrospective comparative study | 85          | 340             | 4 per arch              | 30–40                      | Surgical template            | Immediate and delayed       | Immediate loading | ≤10 mm          | Implant-supported prosthesis-16 | Fixed prosthesis-21          | 1 week         | For 1 month    | Axial: 1.0 ± 0.37 | NA       |
| 10    | Bassi et al.   | Clinical trial | 12          | 48              | 4 per arch              | NA                         | NA                           | Immediate and delayed       | Immediate loading | Unilateral: 41.67% cases | Hybrid metal-acrylic acrylic denture | Natural teeth-6          | 1 year         | 1 year         | Bilateral: 33.3% cases | NA       |
| 11    | Acocella et al. | Retrospective study | 45          | 225             | 5 per arch              | 20–30                      | Guide pins                   | Immediate                  | Immediate loading | NA               | Acrylic resin titanium screw retained | Natural teeth-6          | 1 year         | 4 years        | NA       | NA      |
| S. no. | Authors/journal | Type of study | Sample size | No. of implants in each arch | Angulation of implants (°) | Time of implant placement | Loading protocol | Length of cantilever | Type of provisional prosthesis | Type of opposing dentition | Follow-up interval | Follow-up period | Bone loss | Patient satisfaction |
|-------|-----------------|---------------|-------------|-----------------------------|---------------------------|---------------------------|-----------------|---------------------|-----------------------------|----------------------------|-----------------|----------------|----------|--------------------|
| 12    | Agliardi et al. | Prospective cohort study | 32 | 192 | 6 per arch | 30–45 | NA | Immediate and delayed | NA | Screw retained metal reinforced, acrylic resin interim restoration | Removable prosthesis-6 | 6 months | 3 years | Axial: 1.55 ± 0.31 | Satisfied with both esthetics and function |
| 13    | Malo et al. | Preliminary result | 23 | 92 | 4 per arch | NA | Surgical template | Delayed | Immediate loading | NA | Fixed acrylic complete denture | NA | 10 days | 2 years | Maxilla: 2 mm | Tilted: 1.46 ± 0.19 |
| 14    | Balshi et al. | Retrospective analysis | 152 | 800 | 4 per arch | NA | NA | Immediate and delayed | Immediate loading | NA | Screw retained all acrylic resin | NA | 3 months | 5 years | NA | NA |

Contd...
| S. no. | Authors/journal | Type of study | Sample size | No. of implants | No. of implants in each arch | Angulation of implants (°) | Surgical guide/freehand implant placement | Time of implant placement | Loading protocol | Length of cantilever | Type of provisional prosthesis | Type of opposing dentition | Follow-up interval | Follow-up period | Bone loss | Patient satisfaction |
|-------|----------------|---------------|-------------|----------------|-----------------------------|-----------------------------|---------------------------------|---------------------------|----------------|----------------|-----------------------------|-----------------------------|------------------------|----------------|----------|---------------------|
| 15    | Tealdo et al.  | Pilot study   | 21          | 111            | Maxilla 111                | NA                          | NA                             | Immediate and delayed          | Immediate loading          | NA             | Screw retained fixed acrylic resin | Natural teeth-9          | 6 months               | 1 year          | Mesial site: 1.39 | NA                  |
|       |                |               |             |                |                             |                             |                                 |                           |                           |                |                             |                             |                       |            |                      | Cache                |
|       |                |               |             |                |                             |                             |                                 |                           |                           |                |                             |                             |                       |            |                      |                     |
| 16    | Francetti et al.| Retrospective investigation | 53          | 212            | 4 per arch                 | NA                          | NA                             | Immediate and delayed          | Immediate loading          | NA             | NA                          | Natural teeth and fixed implant-supported prosthesis-3 Complete arch fixed implant-supported prosthesis-6 Natural teeth and RPD-3 | 1 year                   | 5 years               | At 5 years: 1.81 mm | Distal site: 1.35 | NA                  |
|       |                |               |             |                |                             |                             |                                 |                           |                           |                |                             |                             |                       |            |                      |                     |
| 17    | Malo et al.    | Retrospective study | 324         | 1296           | 4 per arch                 | NA                          | Delayed                        | Immediate loading             | Used only in the final prosthesis | Acrylic resin with a titanium cylinder | Implant-supported fixed prosthesis-139 | 6 months                 | 7 years               | At 5 years: 1.81 mm | Average: 1.74 mm   | NA                  |
|       |                |               |             |                |                             |                             |                                 |                           |                           |                |                             |                             |                       |            |                      |                     |

*Contd…*
### Table

| S. no. | Authors/Journal | Type of study | Sample size | No. of implants | No. of implants in each arch | Angulation of implants (°) | Time of implant placement | Loading protocol | Type of provisional prosthesis | Type of opposition dentition | Follow-up interval | Follow-up period | Bone loss (mm) | Patient satisfaction |
|--------|-----------------|---------------|--------------|-----------------|----------------------------|-----------------------------|--------------------------|----------------|-----------------------------|--------------------------|-----------------|----------------|---------------|------------------|
| 18     | Di et al.       | NA            | 69           | 343             | 4 per arch               | NA                         | Immediate                | Immediate loading       | <+ 8 mm         | Acrylic resin               | NA                       | 3 months         | 5 years        | Axial: 0.7 ± 0.2 | Satisfied with the function and esthetics |
| 19     | Sannino et al.  | Retrospective study | 51           | 248             | 4 per arch               | NA                         | Immediate and conventional | Immediate loading       | ≤10 mm          | Acrylic resin               | Implant-supported restoration-11 | 6 months         | 2 years        | Axial- 1.07 ± 0.33 | Tilted- 1.10 ± 0.32 |

**Notes:**
- Fixed prosthesis over natural teeth-26
- Combination of natural teeth and implant-supported fixed prosthesis-38
- Removable prosthesis-81
- Maxillary CD-17
- Natural teeth-12
| S. no. | Authors/journal | Type of study | Sample size | No. of implants | Angulation of implants (°) | No. of implants in each arch | Surgical guide/freehand implant placement | Time of implant placement | Loading protocol | Length of cantilever | Type of provisional prosthesis | Type of opposing dentition | Follow-up interval | Follow-up period | Bone loss | Patient satisfaction |
|--------|-----------------|---------------|-------------|-----------------|---------------------------|-----------------------------|--------------------------------|---------------------------|-------------------|------------------|-----------------------------|-----------------------------|-----------------|----------------|----------|--------------------|
| 20     | Crespi et al.   | Prospective study | 36          | 176             | 30–35                     | NA                         | Immediate and conventional    | Immediate and conventional     | NA                | NA               | Acrylic resin        | NA                          | 3 months         | 3 years        | NA       | Maxilla: NA                |
| 21     | Malo et al.     | Longitudinal study | 245         | 980             | 30–45                     | NA                         | Immediate and conventional    | Immediate and conventional     | NA                | NA               | High-density acrylic resin | Implant-supported fixed prosthesis-100 | 6 months | For 1 year | NA       | NA                     |
|        |                 |               |             |                 |                           |                            |                                |                                |                   |                  | Natural teeth-31        | Fixed prosthesis over natural teeth-21 | 1 year | For 10 years | NA       | NA                     |
|        |                 |               |             |                 |                           |                            |                                |                                |                   |                  | Combination of natural teeth and implant-supported fixed prosthesis-30 | Removable prosthesis-63 |                 |            |         |                     |
| S. no. | Authors/journal | Type of study | Sample size | No. of implants | Angulation of implants (°) | Surgical guide/freehand implant placement | Time of implant placement | Loading protocol | Length of cantilever | Type of provisional prosthesis | Type of opposing dentition | Follow-up interval | Follow-up period | Bone loss | Patient satisfaction |
|-------|-----------------|---------------|-------------|-----------------|-----------------------------|-------------------------------------------|--------------------------|-------------------|-------------------|---------------------------------|------------------------|-------------------|------------------|----------|-------------------|
| 22    | Najafi et al.    | Prospective study | 30          | 156             | 4 per arch                  | NA                                        | Immediate and conventional | Delayed loading | NA                | Fixed metal resin              | Natural teeth-12 | 6 months | 1 year          | 0.84 ± 0.15 | NA                |
|       |                 |               |             |                 |                             |                                           |                          |                   |                   |                                 |                        |                   |                  |          |                   |
| 23    | Hinze et al.     | Prospective clinical study | 37          | 148             | 4 per arch                  | NA                                        | Immediate and conventional | Immediate loading | Right side: 12.47 ± 1.48 | Acrylic resin | Natural teeth-7 | 6 months | 5 years          | 0.82 ± 0.31 | NA                |
|       |                 |               |             |                 |                             |                                           |                          |                   | Left side: 12.28 ± 1.36 |                        | FPD on natural teeth-11 |                   |                  |          |                   |
|       |                 |               |             |                 |                             |                                           |                          |                   | Axial: 0.76 ± 0.49 |                        | Implant-supported fixed partial denture-14 |                   |                  |          |                   |
|       |                 |               |             |                 |                             |                                           |                          |                   | Tilted: 0.76 ± 0.49 |                        | Full arch implant-supported prosthesis-5 |                   |                  |          |                   |
| 24    | Mozzati et al.   | Retrospective analysis | 50          | 200             | 4 per arch                  | NA                                        | Immediate                 | Immediate loading | NA                | Acrylic resin              | NA                    | 1 month | For 6 months     | 1.33 ± 0.36 | Patients were satisfied |
|       |                 |               |             |                 |                             |                                           |                          |                   | NA                |                                 |                        | 6 months | For 2 years      | 1.48 ± 0.39 |                  |
| S. no. | Authors/journal | Type of study | Sample size | No. of implants | Angulation of implants (°) | No. of implants in each arch | Surgical guide/freehand implant placement | Time of implant placement | Loading protocol | Type of provisional prostheses | Type of opposing dentition | Follow-up interval | Follow-up period | Bone loss (mm) | Patient satisfaction |
|-------|-----------------|---------------|-------------|-----------------|---------------------------|-----------------------------|-------------------------------|---------------------------|-----------------|------------------------|--------------------------|-----------------|----------------|---------------|------------------|
| 25    | Galindo et al.  | Retrospective study | 183         | 732             | 4 per arch               | 30                          | NA                           | Immediate and conventional | NA              | Acrylic resin           | NA                      | 10 days         | 1 year          | <1 mm         | NA               |
|       | The International Journal of Oral and Maxillofacial Implants 2012 | | | | | | | | | | | | | |
| 26    | Browaeys et al. | Prospective study | 20          | 80              | 4 per arch               | 20–40                       | Computer-guided surgery     | Conventional              | Immediate loading | Acrylic resin           | NA                      | 1 year          | 3 years         | After 1 year: 1.13 mm | NA               |
|       | Clinical Implant Dentistry and Related Research 2014 | | | | | | Surgical template | | | | | | | | After 3 years: 1.61 mm |
| 27    | Francetti et al. | Prospective study | 62          | 248             | 4 per arch               | 30                          | Freehand placement          | Immediate and conventional | Immediate loading | Right side: Acrylic resin | Removable prosthesis-27 | 6 months        | For 2 years      | Axial: 0.7 ± 0.4  | NA               |
|       | Clinical Implant Dentistry and Related Research 2008 | | | | | | | | | | | | | | Tilted: 0.7 ± 0.5 |

Contd...
| S. no. | Authors/ journal | Type of study | Sample size | No. of implants in each arch | No. of implants | Angulation of implants (°) | Surgical guide/ freehand implant placement | Time of implant placement | Loading protocol | Length of cantilever | Type of provisional prosthesis | Type of opposing dentition | Follow-up interval | Follow-up period | Bone loss | Patient satisfaction |
|-------|-----------------|---------------|-------------|-----------------------------|----------------|---------------------------|------------------------------------------|--------------------------|-------------------|------------------|---------------------------------|-----------------------------|-----------------|-----------------|----------|------------------|
| 28    | Francetti et al. | Prospective study | 47          | 196                         | 4 per arch     | 30                        | Free-hand placement                      | Immediate and conventional | NA                | <8 mm            | Acrylic resin                     | Removable prosthesis-23   | 6 months        | For 2 years    | At 1 year: 1.1 ± 1.1 | NA               |
|       |                 |               |             |                             |                |                           |                                          |                          |                   |                  |                                 | Natural teeth-11          | 1 year          | For 5 years    |                      |                  |
|       |                 |               |             |                             |                |                           |                                          |                          |                   |                  |                                 | Natural teeth and fixed prosthesis on natural teeth-9 | 3 months       | For 7 years    | After 7 years: 1.2 ± 0.3 |                  |
| 29    | Li et al.       | Prospective study | 17          | 80                          | 4 per arch     | 30-40                      | Free-hand placement                      | Immediate and conventional | Immediate loading | <8 mm            | Heat cure acrylic resin             | NA                          | 1 week          | For 1 year    | After 1 year: 0.8 ± 0.4 | NA               |
|       |                 |               |             |                             |                |                           |                                          |                          |                   |                  |                                 | Natural teeth and 2 implant-supported bridge-2 | 3–6 months     | For 7 years    | After 7 years: 1.2 ± 0.3 |                  |

Contd...
| Authors/Journal            | Type of study | Sample size | No. of implants in each arch | No. of implants | Angulation of implants (°) | Surgical guide/freehand implant placement | Type of provisional prosthesis | Type of opposing dentition | Type of prosthesis | Loading protocol | Length of cantilever | Type of oppositional prosthesis | Type of opposing dentition | Length of follow-up period | Bone loss after | Patient satisfaction | Follow-up interval | Follow-up period |
|---------------------------|---------------|-------------|------------------------------|-----------------|---------------------------|------------------------------------------|--------------------------------|---------------------------|----------------|---------------|----------------|--------------------------------|-----------------------------|-----------------------------|-------------------|------------------------|----------------|----------------|
## Rehabilitation of Edentulous Arches with Fixed Prosthesis Supported by Tilted Implants

### Table 1: Summary of Studies

| S. no. | Authors/ journal | Type of study | Sample size | No. of implants | Angulation of implants (°) | Surgical guide/freehand implant placement | Time of implant placement | Loading protocol | Length of cantilever | Type of provisional prosthesis | Type of opposing dentition | Follow-up interval | Follow-up period | Bone loss (mm) | Patient satisfaction |
|--------|------------------|---------------|-------------|-----------------|-----------------|-----------------------------|----------------------------|-----------------|-------------------|-------------------------------|-----------------------------|-------------------|----------------|---------------|-------------------|
| 32     | Piano et al.     | Prospective study | 21          | 84              | <30             | Surgical guide              | Immediate and conventional | Immediate loading   | <15 mm           | Acrylic resin               | Natural teeth with partial removable prosthesis-6 | 1 year | 2 years | 0.34 | NA               |
|        | Clinical Oral Implant Research 2015 | | | | | | | | | | Natural teeth supporting fixed partial prosthesis-3 | | | |
| 33     | Marcello et al.  |                | 17          | 68              | 30–45           | NA                          | NA                         | NA               | NA                | Acrylic resin               | Natural teeth-10 | NA               | 3 years | NA             | NA               |
|        | Implant Dent. 2015 | | | | | | | | | | Implant-supported prosthesis-7 | | | |
Rehabilitation of Edentulous Arches with Fixed Prosthesis Supported by Tilted Implants

The position and angulation of 8 (4.97%) implants were not specified.

**DISCUSSION**

**Article Type**

Out of the 75 articles obtained 33 were selected which fulfilled all the inclusion criteria.

Fourteen\textsuperscript{2,23,25–36} articles (42.424%) were prospective studies of which one (7.14%) was a clinical study\textsuperscript{36} and one (7.14%) a cohort study.\textsuperscript{25} Eleven articles\textsuperscript{1,20,24,37–43} (33.33%) were retrospective studies including one (9.09%) pilot study,\textsuperscript{38} one (9.09%) investigation\textsuperscript{41} and one (9.09%) comparative study.\textsuperscript{39} There was also a clinical report (3.03%),\textsuperscript{44} clinical study (3.03%),\textsuperscript{22} clinical trial (3.03%),\textsuperscript{3} preliminary report (3.03%),\textsuperscript{45} pilot study (3.03%),\textsuperscript{46} and a longitudinal study (3.03%).\textsuperscript{47} Two (6.060%) articles did not mention the type of study conducted.\textsuperscript{48,33} The majority of the articles selected for this review were prospective studies as these types of studies help the clinician to accurately catalog the progress of the treatment.

**Study Population**

A total of 2,398 patients were studied of which 967 (40.681%) were males and 1,235 (51.956%) were females. One hundred and ninety-six (8.17%) did not identify the gender of the patients. An average of 72.67 participants was present in each study. The highest sample size was found to be 324 in the article by Paulo Maló, Miguel de Araújo Nobre, Armando Lopes, Ana Ferro, Inês Gravito\textsuperscript{24} and the lowest was 12 by Bassi, Andrisani, Lico, Ormanier, Arcuri.\textsuperscript{3} The highest number of male participants in a single study was found to be 130\textsuperscript{24} and the lowest was 4.\textsuperscript{33} The highest number of female participants in a single study was 194\textsuperscript{24} and the lowest 7.\textsuperscript{3,33,35} The oldest participant was aged 89 years old and the youngest was 23 years old. The average age of the patients was 57.98 years, which shows that the full mouth implant rehabilitation is not necessarily indicated just for the geriatric or younger age group but can be applied to all age groups. The large sample size helps to get statistically significant results and authenticate the treatment protocol.

**Number of Implants Placed**

A total of 10,300 implants were placed of which 3,489 (33.87%) were placed in the maxillary arch and 6,045 (58.68%) in the mandibular arch. The location of the remaining 766 (7.44%) implants placed were not specified. A total of 5,069 implants (49.21%) were tilted and 5,116 (49.66%) were axial. The maximum number of implants placed in a single study was 1,296 (12.58%)\textsuperscript{24} and the minimum number of implants placed was 48 (0.46%).\textsuperscript{3} The maximum number of implants placed in the maxillary arch in a single study was 968 (0.093%) and 1,296 (12.58%)\textsuperscript{24} in the mandibular arch. The minimum number of implants used in a study was 36 (0.35%) in the maxillary arch and 4 (0.04%) in the mandibular arch.

**Number of Implants Placed Per Arch**

A total of 10,300 implants were placed of which 3,489 (33.87%) were placed in the maxillary arch and 6,045 (58.68%) in the mandibular arch. The location of the remaining 766 (7.44%) implants placed were not specified. A total of 5,069 implants (49.21%) were tilted and 5,116 (49.66%) were axial. The maximum number of implants placed in a single study was 1,296 (12.58%)\textsuperscript{24} and the minimum number of implants placed was 48 (0.46%).\textsuperscript{3} The maximum number of implants placed in the maxillary arch in a single study was 968 (0.093%) and 1,296 (12.58%)\textsuperscript{24} in the mandibular arch. The minimum number of implants used in a study was 36 (0.35%) in the maxillary arch and 4 (0.04%) in the mandibular arch.

**Table 2:**

| S. no. | Type of study          | Number | Percentage |
|--------|------------------------|--------|------------|
| 1      | Prospective Clinical   | 14     | 42.42      |
| 2      | Retrospective Pilot    | 11     | 33.33      |
| 3      | Clinical report        | 1      | 3.03       |
| 4      | Clinical study         | 1      | 3.03       |
| 5      | Clinical trial         | 1      | 3.03       |
| 6      | Preliminary report     | 1      | 3.03       |
| 7      | Pilot study            | 1      | 3.03       |
| 8      | Longitudinal study     | 1      | 3.03       |
| 9      | Not mentioned          | 1      | 3.03       |

**Table 3:**

| S. no. | Type of study          | Number | Percentage |
|--------|------------------------|--------|------------|
| 1      | Prospective Clinical   | 14     | 42.42      |
| 2      | Retrospective Pilot    | 11     | 33.33      |
| 3      | Clinical report        | 1      | 3.03       |
| 4      | Clinical study         | 1      | 3.03       |
| 5      | Clinical trial         | 1      | 3.03       |
| 6      | Preliminary report     | 1      | 3.03       |
| 7      | Pilot study            | 1      | 3.03       |
| 8      | Longitudinal study     | 1      | 3.03       |
| 9      | Not mentioned          | 1      | 3.03       |

**Table 4:**

| S. no. | Implant angulation ($) | No of articles | Percentage |
|--------|------------------------|----------------|------------|
| 1      | 30                     | 12             | 44.44      |
| 2      | 45                     | 6              | 22.22      |
| 3      | 20–30                  | 1              | 3.70       |
| 4      | 20–40                  | 1              | 3.70       |
| 5      | 25–35                  | 1              | 3.70       |
| 6      | 30–35                  | 2              | 7.40       |
| 7      | 30–40                  | 2              | 7.40       |
| 8      | 30–45                  | 5              | 18.51      |

at an angulation. The orientation of 60 (37.27%) implants was not mentioned.

In the maxillary arch, 93 implants (57.76%) failed, out of which 19 (11.80%) implants were axially placed, and 38 (23.60%) implants were tilted. The angulation of the remaining 36 (22.36%) implants was not mentioned.

In the mandibular arch, a total of 60 (37.27%) implants failed, out of which 5 (3.11%) implants were axially placed and 10 (6.21%) implants were tilted. The angulation of 45 (27.95%) implants was not specified.
Implant Angulation
The articles used in this review placed the implants in axial positions as well as in different angles. Few studies placed the implants in multiple angles and few used a specific angle for the implant placement. Twelve (44.44%) articles placed the implants at 30° and six (22.22%) articles placed the implants at 45°. One (3.70%) article placed the implants at angles between 20 and 30°, one (3.70%) article placed the implants at between 20 and 40°, one (3.70%) article placed the implants at 60°, two (7.40%) articles placed the implants at 30° and 35°, two (7.40%) articles placed the implants at 30° and 45°, and five (18.51%) articles placed the implants at angles between 30 and 45°. One (3.70%) article placed the implants at 60°. The use of cantilever should be avoided in the implant-supported prosthesis. The type of opposing dentition influences the treatment plan taken for the patient. The forces acting on the implant-supported prostheses depend on the condition of the opposing dentition. The presence of natural teeth or fixed prosthesis on the opposing arch requires the use of a short cantilever and an increased number of implants. A removable prosthesis on the opposing arch creates a minimum bite force.

Use of Surgical Guide
Four (12.12%) studies used a surgical template for surgery using a flapless approach and three (9.09%) studies used a surgical template with the flap elevation technique. Twenty-six (78.78%) studies did not use surgical templates and employed a freehand implant placement approach.

Time of Implant Placement
Immediate, delayed, and a combination of the two were practiced. Two (6.06%) authors used an immediate placement of implants into the arch after extraction and five (18.51%) authors used a delayed protocol for the placement of the implants. A combination of delayed and immediate implant placement was done by 26 (78.78%) authors.

Loading Protocol
The loading protocol followed by all the authors were different. Six (18.18%) authors loaded the implants immediately after surgery. Four (12.12%) authors loaded the implants 3 hours after surgery, four (12.12%) authors loaded the implants 2–3 hours after surgery, two (6.06%) authors loaded the implants after 4 hours, and two (6.06%) articles loaded the implants after 6 hours. One article loaded the implants within 24 hours after surgery and two (6.06%) articles loaded the implants 24 hours after the surgery. One article loaded the implants within 24 hours after surgery and two (6.06%) articles loaded the implants 48 hours after the surgery. One article loaded the implants within 48 hours and seven (21.21%) after 48 hours. One article loaded the implants 3 days after surgery, and one (3.03%) 2 months after the surgery. A single article loaded the implants on the same day of the surgery. One article did not mention the loading protocol followed.

Presence and Length of Cantilever
The use of cantilever was assessed and it was found that 21 (63.63%) articles declared the use of cantilever during restoration and 12 (36.36%) did not use cantilever during restoration. The longest cantilever used was of 15.20 mm in length and the shortest was of 6.84 mm in length. The use of cantilever should be avoided in complete arch replacement or should be kept to not >2 times the anteroposterior spread or a maximum of 20 mm.

Type of Provisional Restoration/Prosthesis
The type of provisional or temporary restoration was taken into consideration. Eleven (33.33%) articles gave an acrylic resin prosthesis. Five (15.15%) articles gave a screw-retained acrylic prosthesis and three (9.09%) articles gave a screw-retained acrylic prosthesis and two (6.06%) articles gave a acrylic prosthesis without a metal framework. Three (9.09%) studies placed all-acrylic prostheses. One (3.03%) study gave acrylic resin teeth to the patients and another gave acrylic veneered teeth. Acrylic dentures were given in one study and fixed acrylic resin complete denture was given in another study. One study had given acrylic resin with titanium cylinder. Acrylic resin prosthesis with the screw-retained bar-retained restoration was placed in one study. Fixed metal resin prosthesis was placed in an article and heat-cured acrylic resin prosthesis in another study. The type of provisional restoration placed influences the load on the implants which has an impact on the success of the implant treatment.

Type of Opposing Dentition
When the type of opposing dentition was considered it was found that in 311 cases the prosthesis was opposed by the natural dentition. Thirty-nine cases had a combination of natural teeth and fixed prosthesis on the natural dentition. Three hundred and twenty-seven cases had a removable prosthesis opposing the implant-supported prosthesis and 513 cases had implant-supported prosthesis itself on the opposite arch. Eighty-five cases had a fixed prosthesis on natural teeth, three had natural teeth supporting fixed partial prosthesis, and five had natural teeth and implant-supported fixed partial prosthesis. Fifty-six cases were considered to have a complete denture in the opposing arch and three cases had an implant-supported bar-retained overdenture. In 154 cases, the opposing arch was a combination of natural teeth and implant-supported prosthesis. Nineteen cases had a combination of natural teeth and implant-supported prosthesis. Nineteen cases had a combination of natural teeth and implant-supported prosthesis. Fifty-six cases were reported to have a complete denture in the opposing arch and three cases had an implant-supported bar-retained overdenture. In 154 cases, the opposing arch was a combination of natural teeth and implant-supported prosthesis. Nineteen cases had a combination of natural teeth and implant-supported prosthesis. Nineteen cases had a combination of natural teeth and implant-supported prosthesis. Eight cases had a fixed partial dentures or removable partial dentures which were not specified by the authors. The type of opposing dentition influences the treatment plan taken for the patient. The forces acting on the implant-supported prosthesis depend on the condition of the opposing dentition. The presence of natural teeth or fixed prosthesis on the opposing arch requires the use of a short cantilever and an increased number of implants. A removable prosthesis on the opposing arch creates a minimum bite force.

Follow-up Interval
Most of the studies followed the cases at equal time intervals. Few studies followed-up the subjects at short intervals immediately after the treatment and at a longer interval period after some time. Nine (27.27%) studies followed-up with their patients at an interval of less than a month. Twelve (36.36%) articles followed-up with their patients at an interval of 1–3 months. Twenty (60.60%) articles also had a follow-up interval of 4–6 months and 22 (66.67%)
Follow-up Period
The articles selected for this study had a follow-up period of not less than a year. Eleven (33.33%) studies followed up patients for a period of 1 to 2 years after implant placement. Seven (21.21%) articles had followed up their cases for up to 4 years and 11 (33.33%) articles followed up their cases for 5–6 years following implant placement. About four (12.12%) studies maintained patient follow-up for 7 or more years. Patient follow-up helps to carefully evaluate the time of implant failure. The failure of the implant is not a time dependent factor, but most of the implants which failed in the studies did so in the first 6 months after placement (Flowchart 1).

Bone Loss
An implant is said to be a failure if the peri-implant bone loss is >1 mm in the first year after the placement of an implant. The bone loss in the subsequent years should not be >0.2 mm per year. Twenty-five (0.24%) implants reported a peri-implant bone loss of >1 mm. In the maxillary arch, five (20.00%) implants that lost >1 mm peri-implant bone were axially placed and five (20.00%) were placed at an angulation. In the mandibular arch, six (24.00%) implants showed bone loss >1 mm in which two (8.00%) were axially placed implants and two (8.00%) were tilted implants showed bone loss >1 mm. The angulation and location of nine (36.00%) implants were not mentioned in the articles.

Patient Satisfaction
All-on-4 and all-on-6 treatment protocol is one of the widely accepted treatment protocols for the rehabilitation of edentulous patients with high levels of patient satisfaction. Six (18.18%) of the articles assessed patient satisfaction. The patients were completely satisfied with the esthetic and functional outcome of the prosthesis. The ultimate aim of all prosthodontic treatments is patient satisfaction in terms of their appearance, functionality, and comfort of the prosthesis.

Conclusion
The following conclusions were derived from the findings of this review:

- The survival rate of tilted implants at the implant and prosthetic levels is good.
- There is no significant difference between the survival rate of tilted and axial implants at implant and prosthetic levels.
- Tilted implants provide greater surface area for osseointegration, provide greater primary stability, reduce cantilever length, reduce bone resorption, and also reduce the need for bone grafting.
- The angulation of the implant which provided the most success was found to be 30°.

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