Immediate loading of oral implants has been reported as a beneficial treatment protocol in implant dentistry that increases the comfort of the patient. However, documentation in the literature is poor regarding the clinical outcome and the peri-implant bone response of immediately loaded implants compared with the conventional loading protocol placed in different bone qualities. The aim of this report was to present the role of bone quality in the survival rate of implants using conventional or immediate loading according to the literature.

A literature search analysis was performed to demonstrate the survival rate of immediately loaded implants, as well as data from the histologic and histomorphometric evaluation in comparison with conventional loaded implants. This analysis showed high survival rates of immediately loaded implants along with osseointegration, with high percentages of bone-to-implant contacts based on histologic evaluation from human and animal studies of immediately and conventionally loaded implants. This study may provide histologic and clinical evidence of the immediate loading protocol for different bone qualities.

Key Words: immediate loading, literature review, studies
were the first to discuss the possibility of using a fixed partial prosthesis to immediately load implants without compromising long-term implant survival.

Exact indications and considerations for an IL protocol were defined for the first time in 2002 at the World Congress Consensus Meeting in Barcelona. According to this Meeting, immediate (functional or occlusal) loading is defined in the treatment protocol, that is, when implants have been placed in the bone and have been restored with the use of restorations with occlusal contacts within 3–4 days after surgery. Immediate occlusal loading of full-arch mandibular fixed prostheses and overdentures supported by implants was accepted as a therapeutic option; this was supported by adequate clinical documentation. At this Conference, further research was presented regarding different treatment areas and different bone qualities. Unfortunately, very few comparative studies have been conducted. However, although IL of single-tooth implants and fixed partial prostheses in the esthetic zone were accepted treatment options, it was suggested that further research was needed to document long-term success. Moreover, the concept of immediate implant loading in other areas of the oral cavity, with poor bone quality, still required documentation.

Although some reports indicate that IL may be unpredictable with poor bone quality; other studies with different implants, thread designs, and implants surface patterns have demonstrated encouraging results for immediately loaded, nonsplinted, splinted implants placed in regions where bone quality was nonoptimal.

Cochran et al in a more recent Consensus Conference reviewed the requirements for clinical procedures using IL protocols. One important consideration for the success of immediately loaded implants was adequate initial implant stability. Stability of the implant was found to be influenced by various factors, including implant geometry and length, surface morphology, splinting of implants, control of the occlusal load, quality of bone, and absence of detrimental patient habits.

At the microscopic level, bone response is clearly of paramount importance in the determination of clinical success.

Only 4 studies in the literature have evaluated the effects of immediate vs delayed loading on bone-to-implant contact percentages and bone density in areas of poor bone quality, presenting better osseointegration with denser bone around immediately loaded implants or successful clinical results when the immediate loading concept was used in areas with poor bone quality.

Chiapasco and, more recently, Del Fabbro et al cited the necessity for additional well-designed randomized controlled clinical trials. Additional histologic data supporting the success of IL under various clinical conditions are necessary to support more widespread use of this concept in different clinical situations. In addition, the authors of both studies were unable to compare treatment outcomes between immediately vs conventionally loaded implants because of the paucity of controlled studies comparing these 2 protocols.

Therefore, the purpose of the present study was to compare the results of an immediate or delayed implant loading protocol for long-term implant survival by reviewing the literature from 1979–2008. In addition, a review of the histologic literature on the healing response in poor-quality bone was performed, as was an evaluation of the bone-to-implant interface that results from the 2 different protocols.

**Materials and Methods**

A computer search was performed of articles on MEDLINE from 1979 to February 2007. Key words such as immediate function,
immediate loading, delayed loading, dental implants, bone-to-implant contact, bone density, poor bone quality were used alone and/or in combination to search the database.

To find further potentially relevant articles, a precise hand search was performed by reviewing all issues since 1990 of the main journals in the field of Implant Dentistry (Clinical Oral Implants Research, International Journal of Oral and Maxillofacial Implants, International Journal of Periodontics and Restorative Dentistry, Journal of Periodontology, and Clinical Implant Dentistry and Related Research) was performed. Finally, a search was performed of the references of review articles and the most relevant papers.

Inclusion criteria included that all studies required a minimum of 1 year post implant loading or had to contain the histology of the bone implant/interface of immediately loaded implants.

Fifty articles satisfied these criteria and were therefore included in this literature review.

Results

Data analysis showed high numbers of studies on immediate and delayed loading with high implant survival rates (ISRs) (Tables 1 and 2).25–39

The IL of implants was documented in different bone qualities. Of significant interest was the ISR of IL implants in poor bone quality, as documented in the maxillary arch and the posterior mandible (Figures 1a through f).

Histologic results utilizing the IL protocol in animal and human studies showed excellent bone-to-implant contacts (Figures 2 through 5). Histologic and histomorphometric information from the different studies on IL, such as evaluation of bone-to-implant contact (BIC) percentages and bone volume (bone density) of immediately loaded implants, is presented in Table 3 and shows relatively high BIC % levels in different species and humans when the concept if IL is used. Of great importance seems to be the implant thread geometry included in these studies (Table 3).40–43

Discussion

Immediate loading vs delayed loading

The high ISR of immediately loaded implants has significant relevance in that this protocol can reduce treatment time and provide a

<table>
<thead>
<tr>
<th>Study</th>
<th>Area</th>
<th>Loading Period</th>
<th>No. of Implants (Implant System)</th>
<th>ISR, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ledermann22</td>
<td>Mdb</td>
<td>Up to 7 y</td>
<td>476 (Ledermann screw)</td>
<td>91.2</td>
</tr>
<tr>
<td>Schnitman et al33</td>
<td>Mdb</td>
<td>Up to 10 y</td>
<td>28 (Branemark)</td>
<td>85.7</td>
</tr>
<tr>
<td>Tarnow et al34</td>
<td>Mx/Mdb</td>
<td>2.5 y</td>
<td>69 (Branemark, Bonefit, Astra)</td>
<td>97.1</td>
</tr>
<tr>
<td>Branemark et al35</td>
<td>Mdb</td>
<td>3 y</td>
<td>150 (Branemark)</td>
<td>98.0</td>
</tr>
<tr>
<td>Chiapasco et al36</td>
<td>Mdb</td>
<td>2 y</td>
<td>40 (Branemark)</td>
<td>97.5</td>
</tr>
<tr>
<td>Ericsson et al16</td>
<td>Mx/Mdb</td>
<td>5 y</td>
<td>14 (Branemark)</td>
<td>85.7</td>
</tr>
<tr>
<td>Buchs et al17</td>
<td>Mx/Mdb</td>
<td>2 y</td>
<td>142 (Aliva)</td>
<td>93.7</td>
</tr>
<tr>
<td>Chow et al5</td>
<td>Mdb</td>
<td>2 y</td>
<td>123 (Branemark)</td>
<td>98.3</td>
</tr>
<tr>
<td>Grunder et al38</td>
<td>Mx/Mdb</td>
<td>2 y</td>
<td>91 (3i)</td>
<td>92.3</td>
</tr>
<tr>
<td>Testori et al38</td>
<td>Mdb</td>
<td>4 y</td>
<td>92 (3i)</td>
<td>98.9</td>
</tr>
<tr>
<td>Rocci et al71</td>
<td>Mx</td>
<td>3 y</td>
<td>97 (Branemark)</td>
<td>90.7</td>
</tr>
<tr>
<td>Degidi and Piattelli39</td>
<td>Mx/Mdb</td>
<td>Up to 7 y</td>
<td>93 (XIVE)</td>
<td>94.0</td>
</tr>
<tr>
<td>Balshi et al19</td>
<td>Mx</td>
<td>2.8 y</td>
<td>522 (Branemark)</td>
<td>99.0</td>
</tr>
<tr>
<td>Glauser et al31</td>
<td>Mx/Mdb</td>
<td>4 y</td>
<td>102 (Branemark)</td>
<td>97.1</td>
</tr>
<tr>
<td>Van Steenberghe et al20</td>
<td>Mx</td>
<td>12 mo</td>
<td>43 (Branemark)</td>
<td>100.0</td>
</tr>
<tr>
<td>Romanos and Nentwig15</td>
<td>Mdb</td>
<td>2 y</td>
<td>36 (Ankylos)</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>3.58 y</td>
<td>2,118</td>
<td>94.9</td>
</tr>
</tbody>
</table>

*Mx indicates maxilla; Mdb, mandible; ISR, implant survival rate.
definite benefit for patients. There is no doubt that the concept of delayed loading has been used successfully for many years, and therefore the number of placed implants in different studies is higher that the number of immediately loaded implants. In addition, the histologic validity of this concept has been evaluated without differences compared with the IL concept.\textsuperscript{12,13} However, Attard et al\textsuperscript{44} in a prospective longitudinal study investigated IL protocols in terms of clinician-related and patient-based outcomes. The authors reported a significant improvement in satisfaction and quality of life following treatment with implants when the IL treatment protocol was used.

Today, in selected cases, the IL of full-arch mandibular fixed prostheses and overdentures supported by implants placed in healed sites has become accepted as a clinical option. This protocol is supported by a high number of clinical studies. In a meta-analysis of articles from 1966 to 2003 found with MEDLINE, Chiapasco\textsuperscript{23} with an IL protocol showed an ISR of 95% for implant-supported fixed prostheses and 98% for overdentures in the mandible. Recently, in a systematic review of survival rates for immediately loaded dental implants, Del Fabbro et al\textsuperscript{24} reported that 55% of the articles on IL were published in the last 4 years, and the average overall ISR was 96.39%.

Balshi et al\textsuperscript{19} showed a cumulative survival rate of 98.6% for full-arch maxillary immediately loaded implants in 55 patients over an average of 3 years. The same authors discussed the importance of cross-arch stabilization in the outcomes of immediately loaded implants in the maxillary arch. Glauser et al\textsuperscript{21} in a 4-year prospective clinical study on 38 patients evaluated the survival rate of implants for single-tooth replacement and fixed partial prostheses placed predominantly in bones of poor quality. Their results showed a cumulative ISR of 97.1% after 4 years of prosthetic loading. It was concluded that the applied IL protocol, in combination with a slightly tapered implant design and a modified implant surface texture, was shown to be a successful treatment alternative in regions exhibiting bone of poor quality. Other authors emphasized the importance of a progressive thread implant design to achieve good primary stability in areas of bone of poor quality.

Recently, Romanos and Nentwig,\textsuperscript{15} when comparing immediately loaded implants vs delayed loaded implants using a split-mouth design protocol, reported a 100% implant success rate (no bone loss) in a 2-year

\begin{table}
\centering
\caption{Implant survival rates in delayed loaded implants*}
\begin{tabular}{|l|l|l|l|l|l|}
\hline
\textbf{Delayed Loading} & \textbf{Area} & \textbf{Loading Period, y} & \textbf{No. of Implants} & \textbf{ISR} \\
\hline
Adell et al\textsuperscript{25} & Mx/Mdb & 15 & 2,768 & 81% (Mx) \\
 & & & & 91% (Mdb) \\
Albrektsson et al\textsuperscript{26} & Mx/Mdb & 5–7 & 8,139 & 84.9% (Mx) \\
 & & & & 99.1% (Mdb) \\
Zarb and Schmitt\textsuperscript{27} & Mx/Mdb & 5 & 262 & 88.55%† \\
Jemt and Lekholm\textsuperscript{28} & Mx/Mdb & 5 & 259 & 97.2%† \\
Branemark et al\textsuperscript{29} & Mx/Mdb & 10 & 882 & 79.3% (Mx) \\
 & & & & 90.5% (Mdb) \\
Lindquist et al\textsuperscript{30} & Mdb & 15 & 273 & 98.9% \\
Lazzara et al\textsuperscript{31} & Mx/Mdb & 5 & 1,969 & 93.8% (Mx) \\
 & & & & 97% (Mdb) \\
Romeo et al\textsuperscript{8} & Mx/Mdb & 7 & 759 & 94.7% (Mx) \\
 & & & & 95.98% (Mdb) \\
Total & & & & 8.85 & 15.311 & 91.68% \\
\hline
\end{tabular}
\end{table}

\*Mx indicates maxilla; Mdb, mandible; ISR, implant survival rate.
†Authors grouped maxilla and mandible together in results.
prospective clinical study of 12 consecutive cases in the posterior mandible.

**Success criteria**
The parameter most often associated with the success of immediately loaded implants as reported in the literature was adequate implant primary stability of the implants.

Stability of the implant was found to be influenced by factors such as implant surface and (cylindrical, tapered, thread vs non-thread) geometry.  

**Histology/Histomorphometry**
The success of loading protocols may be evaluated on a biologic basis of implant

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**Figure 1.** (a) Occlusal preop view (left: immediately loaded [IL]; right: delayed loaded [DL]). (b) Implant placement and abutment connection for IL. (c) Provisionalization in occlusion immediately after surgery. (d) Panoramic view immediately after surgery (left: immediate loading; right: delayed loading/3 months healing). (e) Peri-implant soft tissues of healthy immediately loaded implants (5 years after loading). (f) Panoramic view 5 years after loading (left: immediately loaded; right: delayed loaded).
integration when BIC bone density within the threads and around the implant is examined at the light microscopic level.

Some authors have reported higher values of BIC on immediately loaded implants when they were compared with submerged or early loaded implants. However, only 3 studies were able to compare BIC% between immediately loaded implants with a delayed loading protocol in a split-mouth design.

Nkenke et al demonstrated higher BIC and peri-implant bone formation when utilizing an immediate vs delayed loading protocol.
protocol in the maxillae of minipigs. The implant sites were prepared with an osteotome technique or spiral drills. Thus, the results reported must be carefully interpreted in that the implant site preparation may have significantly influenced the histomorphometric analysis.

Romanos et al\textsuperscript{12} studied the bone-implant interface of sandblasted implants in a split-mouth design in \textit{Macaca fascicularis} monkeys. They showed no differences in BIC values, although percentages of mineralized bone volume (bone density) within the threads of the implants were statistically significantly higher in immediately loaded implants compared with delayed loaded implants. In another comparative study with unloaded implants, investigators showed higher BIC when implants were delayed or immediately loaded.\textsuperscript{13}

Although bone volume was not often assessed in the literature reviewed, many authors have found active bone remodeling when the implant was subjected to loading.\textsuperscript{9–14,17,40–43}

Ledermann et al\textsuperscript{9}, in the case of a 95-year-old patient, reported dense compact bone surrounding the implant with signs of increased osteoblast activity at the microscopic level. Furthermore, additional studies by Romanos et al\textsuperscript{14} presented limited histologic data from retrieved immediately loaded implants in humans; these showed a high BIC\% level, independent of the implant design and surface. Romanos and Johansson\textsuperscript{43} reported an excellent apposition of bone around immediately loaded implants with a progressive thread design in an autopsy of an edentulous heavy smoker 7 months after loading with 6 implants in the maxilla and 6 implants in the mandible.

On the basis of these observations, immediate implant loading may stimulate bone formation, as shown in animal and human studies. Adequate biomechanical force transfer between an implant and surrounding tissues is essential for implant osseointegration. For this reason, implant design characteristics are critical to peri-implant bone formation when an IL protocol is used.\textsuperscript{12–15,40,45,47,48}

Additional data from the orthopedic literature show that new bone formation and active remodeling may be observed when the bone is mechanically

<table>
<thead>
<tr>
<th>Study</th>
<th>Area</th>
<th>System</th>
<th>Species</th>
<th>BIC (%)</th>
<th>Bone Volume (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ledermann et al\textsuperscript{9}</td>
<td>Mdb</td>
<td>TPS Straumann</td>
<td>Human</td>
<td>76.4</td>
<td>NR</td>
</tr>
<tr>
<td>Piattelli et al\textsuperscript{40}</td>
<td>Posterior Mx and posterior Mdb</td>
<td>TPS Straumann</td>
<td>Monkeys</td>
<td>67.3</td>
<td>73.2</td>
</tr>
<tr>
<td>Testori et al\textsuperscript{41}</td>
<td>Mdb</td>
<td>Osseotide (3i)</td>
<td>Human</td>
<td>64.2</td>
<td>NR</td>
</tr>
<tr>
<td>Romanos et al\textsuperscript{12}</td>
<td>Posterior Mdb</td>
<td>Ankylos (Dentsply)</td>
<td>Monkey</td>
<td>64.25</td>
<td>76.95</td>
</tr>
<tr>
<td>Romanos et al\textsuperscript{13}</td>
<td>Posterior Mdb</td>
<td>Ankylos (Dentsply)</td>
<td>Monkeys</td>
<td>64.25</td>
<td>76.95</td>
</tr>
<tr>
<td>Rocci et al\textsuperscript{11}</td>
<td>Posterior Mdb</td>
<td>TiUnite (Nobel Biocare)</td>
<td>Humans</td>
<td>92.9</td>
<td>84.9</td>
</tr>
<tr>
<td>Froum et al\textsuperscript{42}</td>
<td></td>
<td>Transitional implants (Dentatus)</td>
<td>Humans</td>
<td>52.9</td>
<td>NR</td>
</tr>
<tr>
<td>Nkenke et al\textsuperscript{17}</td>
<td>Mx</td>
<td>Xive implants (Friadent)</td>
<td>Minipigs</td>
<td>69</td>
<td>78.50</td>
</tr>
<tr>
<td>Romanos et al\textsuperscript{13}</td>
<td>Mx/Mdb</td>
<td>Osseotide (3i)</td>
<td>Humans</td>
<td>66.8</td>
<td>NR</td>
</tr>
<tr>
<td>Romanos and Johansson\textsuperscript{43}</td>
<td>Mx/Mdb</td>
<td>TiUnite (Nobel Biocare)</td>
<td>Ankylos (Dentsply)</td>
<td>51</td>
<td>52</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td></td>
<td></td>
<td>67.2</td>
<td>73.8</td>
</tr>
</tbody>
</table>

\footnotesize*Mx indicates maxilla; Mdb, mandible; BIC, bone to implant contact; NR, not reported.*
stimulated. In orthopedics, osteosynthesis screws with thread designs are used for fracture therapy, providing in a similar way as in implant dentistry information about successful healing in the loaded bones, especially with poor bone quality, as in the hollow bones (tibia, etc.).³⁹,⁵⁰

Examination of the relevant articles from 2003 to 2008 showed the overall ISR with use of the IL protocol ranging between 90% and 95%. These results are similar to those utilizing the traditional delayed loading protocol (delayed loaded 92%; immediately loaded 94.9%; Tables 1 and 2). Further research is encouraged to assess the exact clinical indications and long-term success rates of implants placed in bone of poor quality with an IL protocol.

**Conclusion**

In addition to the benefits that an IL protocol can provide to the patient, long-term outcomes have been reported to be favorable even in areas where bone quality is not adequate. The overall implant survival rate of immediately loaded implants is similar to long-term results achieved with the conventional 2-stage implant protocol. Histologic evidence based on human and animal studies reinforces the idea that osseointegration with implants under immediate functional occlusal loading can be successfully achieved.

**Abbreviations**

BIC: bone-to-implant contact
IL: immediate loading
ISR: implant survival rate

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