The success of dental implants and osseointegration has long been evaluated by numerous clinical studies.1–3 The main focus of studies regarding dental implants has begun shifting toward the quality of implant success and survival rates rather than merely success and survival rates. One of the most important aspects related to the success of dental implants is the marginal bone level maintenance.2,4,5 After the placement of an implant, a remodeling process takes place in the bone around the implant.2 As a result of remodeling, a certain amount of marginal bone loss is considered biologic. Among the opinions about thresholds for bone loss, the criteria of Albrektsson et al,1 which claims “marginal bone loss of less than 1.5 mm during the first year after implant placement and less of 0.2 mm annually in the following years is considered physiological and acceptable for satisfactory results,” is still regarded as a reference today. However, recent studies point out that the marginal bone loss rate could be even less than previously mentioned values due to prompt developments in dental implants.2,6 Several reasons may be the cause of bone loss around implants. There have been different possible hypotheses stated for early and long-term bone loss, which may vary from surgical trauma, occlusal overload, infection, violation of the biologic width, and biomechanical and biologic aspects of the implant collar design together with the microgap (the implant-abutment interface) position.7–10

It has been shown that a firm peri-implant mucosal width is essential to allow a good epithelial and

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**Purpose:** This clinical study was conducted to compare the influence of a platform-switched bone-level implant and a platform-matched tissue-level implant on marginal bone loss during the first year after loading. **Materials and Methods:** Edentulous subjects who applied for two-implant–retained mandibular overdentures and showing sufficient bone volume for implants with 4.3-mm diameter and 12-mm length were enrolled. For standardization reasons, all subjects received a platform-matched tissue-level implant and a platform-switched bone-level implant in the anterior mandible. Since implants from the same manufacturer were used, both implants had identical implant thread designs and surface properties. All subjects received two-implant–retained mandibular overdentures with opposing maxillary complete dentures, and the implants were loaded after 6 weeks. Marginal bone loss was monitored via panoramic radiographs obtained immediately after loading and at the 6- and 12-month recalls after implant loading, and periodontal parameters, such as pocket probing depths, Plaque Index scores, and bleeding on probing, were also measured and recorded. **Results:** Twenty-six patients received 26 bone-level and 26 tissue-level implants. No statistically significant differences were detected between the bone loss of the two groups for all the measurements (P > .05). Additionally, no significant difference was detected between the measured periodontal parameters of the two groups (P > .05). **Conclusion:** Within the limitations of this prospective clinical study with a follow-up time of 12 months, it can be concluded that the platform-switching bone-level design and the platform-matching tissue-level design show similar bone loss in the anterior edentulous mandible. Int J Oral Maxillofac Implants 2021;36:945–951. doi: 10.11607/jomi.8891

**Keywords:** biologic width, bone level, implant collar design, marginal bone loss, platform switching, tissue level

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analyses revealed less bone loss around platform-switching implants compared with implants placed at the crestal or subcrestal levels due to the concept of fixed biologic width. However, to achieve esthetics in anterior or visible posterior regions, implants should be placed deeper into the crest to mask the metal components and to deliver an adequate emergence profile. Therefore, in these regions, it was decided to place a BL implant deeper into the bone instead of a TL implant. As the implant-abutment interface, which is called the microgap, went subcrestally, the resultant bacterial contamination of the interface and an accompanying inflammatory infiltrate occurred, which in turn provoked marginal bone loss. However, after the partly coincidental discovery of platform-switching designs due to an adjournment of wider prosthetic component production, horizontal offset of the implant-abutment interface could be maintained, which had been provided vertically in TL implants. In this manner, inward position and mismatch of the implant-abutment interface could displace it further from the alveolar bone and increase the surface area to where the soft tissues can attach and establish a proper biologic width. Subsequently, much better marginal bone level maintenance could be achieved in platform-switching bone-level implants, and many manufacturers have changed their product range. After the discovery of platform switching, TL and BL implants have been manufactured with two different implant-abutment junctions. TL implants use abutments with matching platforms, whereas a mismatch, platform switching, is used in BL implants. Several clinical studies showed less bone loss with platform-switching implants. Some animal studies even showed bone deposition when platform-switching implants were used. Moreover, the results of conducted systematic reviews and meta-analyses revealed less bone loss around platform-switched implants compared with platform-matched implants.

While the fact that platform-switching implants are more favorable than platform-matched connections could be shown in many studies and aforementioned systematic reviews, the authors appealed that more clinical trials are needed to confirm which implant collar design is superior in terms of marginal bone loss. It should be pointed out that TL implants also have some benefits, such as ease of hygiene maintenance, especially on the implant-abutment junction, which may prevent peri-implant mucositis and subsequent peri-implantitis. This may be an important issue, inducing the marginal bone loss of implants retaining overdentures, especially for elder patients who have difficulties in manual dexterity. Additionally, it has been shown that TL implants can be preferred in patients with inadequate keratinized mucosa width around the implants, which has been particularly observed when inserted in the edentulous anterior mandible. Owing to these observations, some manufacturers even manufactured interchangeable prosthetic components changing a BL implant to TL. Additionally, as far as the authors know, there exists no clinical study investigating the influence of the platform-switching BL design on bone loss when the implants are inserted in the anterior mandible to retain overdentures. Therefore, this prospective study was conducted to examine the two different implant collar designs with two different implant-abutment interfaces from the standpoint of bone loss when inserted in the anterior mandible to retain overdentures.

**MATERIALS AND METHODS**

**Patient Selection**

Edentulous patients applying for a prosthetic solution to the prosthodontic department of a university clinic who accepted the proposed treatment were chosen as candidates to be included in the study group. Each patient was planned to receive a maxillary complete denture and a mandibular two-implant–retained overdenture with locator attachments, in a treatment modality, as pointed out in the McGill as well as the York Consensus. The inclusion criteria were as follows:

1. Absence of any systemic contraindication
2. Patients giving their consent to be present at the recall sessions
3. Showing sufficient bone volume for implants with 4.3-mm diameter and 12-mm length during clinical and radiographic examination

As decided, in a 1-year period for recruiting, 28 patients fulfilling these standards were involved. The study was approved by the university institutional review board, and all the included subjects gave informed consent according to the requirements of the Helsinki Declaration (reference no. 1815).

**Treatment**

All subjects received one 4.3-mm-wide, 12-mm-long TL implant (Dentis i-Clean Tapered Implant) in the
mandibular left canine, and one 4.3-mm-wide, 12-mm-long BL implant (Dentis s-Clean Tapered implant) in the mandibular right canine positions. All the implants belonged to the same manufacturer (Dentis) and have identical thread designs and resorbable blast media surfaces. TL implants had internal-octagon platform-matched abutment connections, whereas the BL implants had internal-hexagon platform-switched abutment connections. The surgery was performed under local anesthesia with an elevated mucoperiosteal flap for implant insertion by a qualified oral and maxillofacial surgeon (H.B.) blinded to the study protocol. All the implants were placed with the identical drilling protocol and were left to transgingival healing by suturing for primary wound closure around the healing abutments (Dentis). Care was taken to achieve a parallel insertion of both implants in order to obtain better retention and prevent early retention loss due to wear of the inserts.

Four weeks after surgery, a qualified prosthodontist (O.E.) fabricated conventional maxillary and mandibular dentures by means of a common prosthetic method using functional impressions in order to extend the denture base maximally, and these were delivered to the subjects. Care was taken to prevent contact of the healing abutments to the mandibular dentures in order to guarantee an osseointegration free from interference. In the following 2 weeks, the control sessions for the conventional complete dentures were accomplished so that the patients had no more complaints. At the sixth week, following the early loading protocol, locator abutments with suitable gingival heights were screwed with an insertion torque of 25 Ncm on the implants, the locator attachments were connected to the mandibular dentures with the direct processing method using an autopolymerizing acrylic resin (Paladur, Heraeus Kulzer), and the black provisional inserts were replaced with medium retentive pink inserts before delivery of the mandibular overdentures.

Measurement of Marginal Bone Loss
Three digital panoramic radiographs (Kodak 8000 Digital Panoramic System, Carestream Health) were taken from each patient directly after loading and 6 and 12 months after loading (Fig 1). Marginal bone loss was measured on each aforementioned panoramic radiograph and evaluated at 10× enlargement by means of a software program (CorelDraw version 11.0, Corel Corp and Coral Ltd). The actual implant collar diameter was used as the reference point. The space between the supercristally widest part of the implant and the crestal bone was analyzed on the enlarged images. To account for variability, the implant collar diameter was measured and compared with the actual dimensions, and the ratios were calculated to adjust for distortion. Bone

losses were calculated by applying the found distortion coefficient.

Evaluation of Peri-implant Soft Tissue Conditions
For each implant, there was a clinical examination parallel to the radiographic evaluation at the 6- and 12-months recalls. Pocket probing depths were recorded. Plaque Index and bleeding on probing were measured and scored according to the index proposed by Mombelli et al.

Statistical Analysis
For the statistical analysis of the results, SPSS (Statistical Package for Social Sciences; v. 19.0 for Windows, IBM) was used. The sample size was selected with the outcome of an applied power analysis. Aside from descriptive statistics (means and standard deviations), considering the comparison of BL and TL implants in terms of marginal bone loss and periodontal parameters, the Student t test (normally distributed) and Wilcoxon test (non-normally distributed) were used. The correlations between pocket probing depths, Plaque Index, and bleeding on probing scores and marginal bone loss were tested with the Pearson correlation analyses. Differences were considered statistically significant at $P < .05$.

RESULTS
Two subjects were excluded from the study, since two BL implants were lost due to failed osseointegration during the early healing period. Finally, 26 subjects (12 women, 14 men; mean age: 69.50 ± 9.69 years) with 52 implants were included, which corresponded to a power of 0.81 ($P = .05$).

The mean bone loss values are presented in Table 1. No statistical differences were observed between the BL and TL implants at all the measurement intervals ($P > .05$). The mean periodontal measures are presented...
Bleeding on probing was seen at 9 BL implants and 8 TL implants at 6 months and 10 BL implants and 11 TL implants at 12 months on the mesial parts. Distal bleeding on probing was seen at 8 BL implants and 9 TL implants at 6 months and 11 BL implants and 11 TL implants at 12 months. All the observed bleedings were scored as 1 according to the index proposed by Mombelli et al. No statistical differences were observed between the BL and TL implants at all the measurement intervals (P > .05). The correlation of periodontal parameters with bone loss did not show any significance (P > .05), except the Plaque Index and bone loss of BL implants at 12 months, which revealed a 48.1% significant positive correlation on the mesial and a 41.4% significant positive correlation on the distal regions (P < .05; Table 3).

**DISCUSSION**

The aim of the present study was to evaluate the difference between TL and BL implants for marginal bone loss as well as for the condition of the peri-implant tissues. It is well-known that because of the physiologic remodeling process, the highest bone loss happens in the first year after implant placement and immediately commences. Therefore, the marginal bone loss of the two implant collar designs during the first year, which has utmost importance, was presented in the present study.

The marginal bone loss rate has been considered as the major part of the implant success index, since it can influence the esthetics as well as the peri-implant health later. The results of the present study showed that both BL and TL implants had a marginal bone loss below 1 mm 1 year after loading (Table 1), which is in the range of the proposed success criteria and in accordance with studies that evaluated implants retaining mandibular overdentures.

Measurement of bone loss from baseline at every follow-up time has been recommended. The time of prosthetic loading was preferred as the baseline marginal bone loss measurement point of each implant instead of the time of implant insertion in the present study. It has been shown that marginal bone level changes are caused by remodeling after surgery, which may be influenced by surface properties or thread designs, which were identical in BL and TL implants, rather than being coherent to the implant collar type or implant-abutment connections.

The implant-abutment complex is reported to play a key role in the relation to the biologic width and thus marginal bone levels and long-term implant success and implant survival. A design that respects the biologic width seems to be more advantageous for marginal bone level maintenance. The present results

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<th>Table 1 Mean Marginal Bone Loss at 6 and 12 Months</th>
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<td>Distal Baseline-6 mo</td>
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Paired-sample t test.

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<th>Table 2 Mean Pocket Probing Depth, Plaque Index, and Bleeding on Probing Scores at 6 and 12 Months</th>
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Wilcoxon signed-rank test.

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<th>Table 3 Correlation of Periodontal Parameters with Marginal Bone Loss at 6 and 12 Months</th>
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Pearson correlation analyses. *Statistically significant.
indicated that both platform-switching BL and platform-matching TL implants showed similar bone loss. This result is contradictory to the results of three systematic reviews\textsuperscript{24–26} that found lower bone loss around dental implants with platform-switching designs. However, all of them reported significant heterogeneity of the included studies and noted possible publication bias.\textsuperscript{24–26} The present results correspond to the results of a systematic review comparing bone loss rates of TL and BL implants.\textsuperscript{46} However, in this review, some of the BL implants used in the included studies did not incorporate platform-switched abutment connections. A more recent systematic review and meta-analyses\textsuperscript{41} comparing the implants placed at subcrestal and crestal levels found no significant differences in terms of marginal bone loss, confirming the results of the present study. However, the included studies in this review\textsuperscript{41} also had heterogeneity. Only 5 of the 16 studies in this review\textsuperscript{41} used the concept of platform switching, and therefore, it is not possible to comment on the implant-abutment interface relying on these results.

Panoramic radiographs are usually preferred for the evaluation of bone loss around implants retaining mandibular overdentures instead of periapical radiographs because intraoral film holders, which may also be mounted to the implants for standardization, can be very painful when used in edentulous mandibles because of bone resorption and shallow lingual sulcus.\textsuperscript{35,42,43} It was reported that if the real length of the structure on the panoramic radiograph is known, it can be proportionalized correctly.\textsuperscript{44} Moreover, it has been indicated that with panoramic radiographs, it is possible to measure the point of bone attachment to implant threads.\textsuperscript{45} Therefore, digital panoramic radiography was preferred to measure the marginal bone loss in the present study.

In the beginning of the study, of the 56 implants, 2 BL implants were lost because of preloading failure, accommodating implant success rates of 97.3\% in BL and 100\% in TL groups. However, because of the split-mouth design, it was not possible to monitor the TL implants alone in the two subjects with the failures. Therefore, these two subjects were obliged to be excluded, and considering the final 52 implants included, both the BL and TL groups showed success rates of 100\% during the 12-month observation period. Peri-implant soft tissue evaluation also was performed during this study as the secondary outcome. No significance was detected between the periodontal values of TL and BL implants, which is not surprising and is in accordance with the results of other studies comparing platform-switching and platform-matching designs\textsuperscript{17} or TL and BL implants.\textsuperscript{46} It has been shown that these measurements, such as probing depths, Plaque Index, and bleeding scores, provide very limited information, unlike the natural teeth.\textsuperscript{47} However, significant increases in probing depths and bleeding on probing from the junctional epithelium have been considered an early symptom of peri-implantitis.\textsuperscript{47,48} Also, microbiologic studies have shown that pockets 5 mm or deeper are serious signs of infection around implants.\textsuperscript{47,49} Nevertheless, the present results showed no symptoms of mucositis or peri-implantitis according to the Sixth European Workshop on Periodontology definitions in any of the implants during the observation period.\textsuperscript{50} Additionally, no correlations were found between the probing depths and bleeding scores and bone loss. This may be due to the low incidence of bone loss and periodontal scores and is in accordance with the results of other studies. However, after 1 year of prosthetic loading, the Plaque Index of BL implants showed a moderate positive correlation with bone loss. Plaque accumulation in subcrestal levels in BL implants might have caused this correlation. A plastic probe with a 0.5-mm tip diameter is suggested in order to not exert high forces and violate the healthy peri-implant soft tissues.\textsuperscript{47} Therefore, in the present study, plastic probes with 0.5-mm tip diameters were used for monitoring pocket probing.

According to the systematic reviews mentioned,\textsuperscript{24–26} it may be concluded that platform-switched implants show significantly greater bone stability and peri-implant soft tissue health than platform-matched implants. Platform switching is suspected to help improve the peri-implant soft tissue stability and maintain the biologic width.\textsuperscript{51} However, in the present study, mismatching the abutments did not influence the bone loss rates. The ease of hygiene maintenance and the superior properties of TL implants when an inadequate keratinized mucosa width is present in the edentulous anterior mandible may have neutralized the possible negative effects of a platform-matched system. However, it should be kept in mind that the anterior mandible, where the implants were inserted in the present study, typically has high bone density,\textsuperscript{33} and these results may not hold true for other regions of the mandible and maxilla with lower bone density. In order to merely compare the collar design, further studies including implants with identical implant-abutment interfaces should be conducted.

Some study design features in this present investigation must be seriously considered. To the authors’ knowledge, this is the first split-mouth design where platform-switching BL and platform-matching TL implants with equal outer geometry and surface properties were used for comparison, permitting a standardized condition. Additionally, it has been shown that the split-mouth design applied in the present study excludes most of the sources of bias that happen in other clinical studies, making it more valuable.\textsuperscript{52}
The biologic width—respecting design of both implant types evaluated in this study seems to result in similar marginal bone level changes 1 year after loading. This study has two limitations: (1) the short observation period because of the ongoing status of the study and (2) the restriction of the observation area to the anterior edentulous mandible, where the bone density is highest. To be able to draw more reliable solutions, it is much better to conduct a randomized controlled study instead of the present nonrandomized study on more participants with a longer observation period. Furthermore, studies analyzing the behavior of the surrounding bone of the implant in different regions of the mouth and additionally with fixed partial or complete dentures could be helpful in finding answers to this multifactorial clinical fact.

CONCLUSIONS

Within the limits of this prospective split-mouth trial, it can be concluded that both a BL design and TL design connection to the marginal bone.

ACKNOWLEDGMENTS

The authors declare that they do not have any conflict of interest.

REFERENCES