Long-term implant performance and patients’ satisfaction in oligodontia

Marieke A.P. Filiusa,⁎, Arjan Vissinka, Marco S. Cuneb, Gerry M. Raghoebara, Anita Vissera

a Department of Oral and Maxillofacial Surgery, University Medical Center Groningen and University of Groningen, PO Box 30.001, NL-9700 RB, Groningen, The Netherlands
b Department of Fixed and Removable Prosthodontics and Biomaterials, Center for Dentistry and Oral Hygiene, University Medical Center Groningen and University of Groningen, PO Box 30.001, NL-9700 RB, Groningen, The Netherlands

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ABSTRACT

Objectives: To assess long-term (≥10 years) implant survival, peri-implant health, patients’ satisfaction and oral health related quality of life (OHQoL) in oligodontia patients rehabilitated with implant-based fixed prosthodontics.

Methods: All oligodontia patients treated ≥10 years previously with implant-based fixed prosthodontics at the University Medical Center Groningen, The Netherlands, were approached to participate. Clinical (plaque index, bleeding index, pocket probing depth) and radiographic (marginal bone level) data were collected between February and May 2016. Surgical implant details (e.g., bone augmentation) and implant loss were recalled from the medical records. Patients completed a satisfaction questionnaire (maximum score 10, high score favourable satisfaction) and the Oral Health Impact Profile (OHIP-NL49, maximum score 196, low score favourable satisfaction) to rate OHQoL. Implant survival was expressed according to Kaplan Meier. The Mann-Whitney U Test was used for the other analyses.

Results: Forty-one patients had been treated with implant-based fixed prosthodontics (n = 258) ≥10 years previously. Cumulative 10-year implant survival of these 41 patients was 89.1% (95%CI 85.2–93.0%). Twenty-eight of them (n = 163 implants) were willing to visit us for additional clinical and radiographic assessments. In these 28 patients, highest peri-implant bone loss was observed for implants placed in augmented bone (p < 0.001). Peri-implant mucositis (65.4%) and peri-implantitis (16.1%) were rather common. Patients’ satisfaction (8.3 ± 1.5) and OHIP-NL49 scores (32.6 ± 30.1) were favourable and not associated with number of agenetic teeth (≤10 versus >10).

Conclusions: Long-term survival, satisfaction and OHQoL results reveal that implant treatment is a predictable and satisfactory treatment modality for oligodontia, although peri-implant mucositis and peri-implantitis are common.

Clinical significance: This study showed unique long-term (≥10 years) results about implant survival, peri-implant health, patients’ satisfaction and OHQoL in oligodontia patients rehabilitated with implant-based fixed prosthodontics.

1. Introduction

Oligodontia is the congenital absence of six or more permanent teeth, excluding third molars [1]. Oligodontia patients commonly suffer from functional and aesthetic problems due to the high number of missing teeth and usually need rather complex oral rehabilitation.

It has been reported that implant treatment is a favourable option to functionally and aesthetically rehabilitate oligodontia patients [2], but the long-term performance of implant-based rehabilitations in such patients is not known yet. Knowledge concerning the long-term implant performance for oligodontia patients is eagerly needed as, in comparison to non-compromised patients, bone augmentation is more often required as the native bone is vertically and horizontally under-developed in areas with the missing teeth. It is well known that implant survival is lower in areas needing bone augmentation. Therefore, it is presumed, but not yet proven, that the bone quality differs between oligodontia patients and non-compromised patients, which could be an additional factor affecting implant survival. The lack of native bone, the high need for bone augmentation and a possible different bone quality may also compromise peri-implant health with potentially a higher risk on the onset and/or progression of peri-implant mucositis and peri-implantitis. Peri-implant mucositis and peri-implantitis are common

⁎ Corresponding author.
E-mail address: m.a.p.filius@umcg.nl (M.A.P. Filius).

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late phenomena in non-compromised patients with dental implants that may jeopardize long-term function and have an impact on long-term cost-effectiveness [3–5]. The lack of external validity due to the complex nature of the dental state prohibits translation of these findings in non-compromised patients to a population of oligodontia patients. Such data are eagerly awaited because oligodontia patients often need dental implants. Moreover, the congenitally absence of teeth negatively impacts oral health related quality of life (OHQoL) [6,7]. It has been shown that absence of several teeth negatively affects well-being, oral function and aesthetics of oligodontia patients [6]. It is presumed that implant-based fixed prostodontics will result in better oral function and aesthetics in these patients.

To adequately advise oligodontia patients and dental professionals about the expectations of implant-based fixed prostodontic rehabilitation in oligodontia, insight is needed into long-term implant performance in these patients. This includes the condition of the peri-implant tissues as well as the factors that may potentially affect the treatment outcome, e.g., the need for bone augmentation surgery. Such data are lacking in literature. Therefore, we performed a study to assess the long-term (>10 years) implant survival, peri-implant health, patients’ satisfaction and OHQoL in oligodontia patients rehabilitated with implant-based fixed prostodontics.

2. Materials & methods

2.1. Treatment schedule

2.1.1. Surgical procedure

Implants were placed after growth was finished. In the early days, when treatment need was high and the patient was younger than 18 years of age, a radiograph of the carpal and tarsal bones of the hands was made. When the cartilaginous zones of the epiphyses became obliterated, it was presumed that no further lengthening of the bones would occur. Later on, no implants were placed before the age of 18. All implants were placed according to the manufacturer’s protocol by the same surgeon (GMR). Bone augmentation was performed, as and when required, during the same surgical procedure, unless the patients needed extensive bone augmentation. In those cases, augmentation surgery was performed prior to implant placement and the implants were placed four months after augmentation (see Table 1).

2.1.2. Prosthetic procedure

After an osseointegration period of 3 months, the implants were uncovered and implant-based fixed suprastructures were provided (single crown or fixed dental prostheses, see Table 1).

2.2. Patient selection

All oligodontia patients treated ≥10 years previously with dental implants (Nobel Biocare implants, Gothenborg, Sweden) and fixed prostodontics at the department Oral and Maxillofacial Surgery of the University Medical Center Groningen (UMCG), Groningen, The Netherlands, were identified and contacted by mail. Patients who did not respond were contacted by telephone. Those who could not be reached by any means were excluded. Routinely, three years after providing the patients with the fixed prostodontics, the general practitioners of the patients were asked to take over routine dental care and follow-up.

The responding patients came to the hospital and were asked if they had any complaints regarding their implants over the period since their last hospital visit. Subsequently, with permission of the patient, a thorough clinical and radiographic implant examination was performed. All clinical and radiographic data were collected between February and May 2016. The need for bone augmentation, implant loss and its presumed cause were recalled from the medical records. As this research was an evaluation of routine dental care, the medical ethical committee of the University Medical Center Groningen granted this study an exemption (M16.188270).

2.2.1. Implant survival

The cumulative survival was calculated for all implants placed ≥10 years previously, i.e., from the time of placement of the implants until the date of implant loss or patients’ last visit to the UMCG or general practitioner.

2.2.2. Clinical assessments

The following clinical parameters were scored during the clinical examination:

- **Plaque according to the modified plaque index** [8]: 0 = No visible plaque; 1 = Plaque only recognized by running a periodontal probe across the smooth marginal surface of the implant; 2 = Plaque can be seen by the naked eye; 3 = Abundance of soft matter.
- **Bleeding on probing (bleeding index)** according to the modified sulcus bleeding index [8]: 0 = No bleeding when a periodontal probe is passed along the gingival margin; 1 = Isolated bleeding spots visible; 2 = Blood forms a confluent red line on the gingival margin; 3 = Heavy or profuse bleeding.
- **Probing pocket depth (PPD)**: Pocket probing depth was assessed at six sites per implant (distobuccal, buccal, mesiobuccal, distolingual, lingual, mesiolingual) using a manual standardized pressure periodontal probe (Click-ProbeR, Kerr, Bioggio, Switzerland), measured to the nearest mm.

2.2.3. Marginal bone loss

Panoramic radiographs and standardized intra-oral radiographs (baseline, made shortly after completion of the prostodontic rehabilitation and current situation) of each patient were uploaded in ImageJ [9].

2.2.4. Peri-implant mucositis and peri-implantitis

Peri-implant mucositis was defined as bleeding upon probing with or without suppuration and <2 mm radiographic bone loss. Peri-implantitis was defined as bleeding upon probing with or without suppuration and ≥2 mm radiographic bone loss [10,11]. The translation

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**Table 1**

<table>
<thead>
<tr>
<th>Patient information</th>
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<tr>
<td>Number of patients</td>
<td>28</td>
</tr>
<tr>
<td>Current median age, years (IQR)</td>
<td>33 [31,39]</td>
</tr>
<tr>
<td>Gender (male/female)</td>
<td>12/16</td>
</tr>
<tr>
<td>Median number of agenetic teeth (third molars excluded) (IQR)</td>
<td>10 [8,14]</td>
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</table>

<table>
<thead>
<tr>
<th>Surgical information</th>
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</thead>
<tbody>
<tr>
<td>Total number of placed implants ≥10 years ago</td>
<td>184</td>
</tr>
<tr>
<td>Median age at implant placement, years (IQR)</td>
<td>20 [19,21]</td>
</tr>
<tr>
<td>Number of implants placed in regions were bone augmentation was performed (% of 184), with the following donor regions: intra-oral bone (%)</td>
<td>96 (52%) (in 23 patients)</td>
</tr>
<tr>
<td>extra-oral bone (%)</td>
<td>31 (32%)</td>
</tr>
<tr>
<td>Number of implants placed in regions were bone augmentation was performed as a pre-implant procedure</td>
<td>65 (68%)</td>
</tr>
<tr>
<td>Number of implants placed simultaneously with bone augmentation</td>
<td>61 (64%)</td>
</tr>
<tr>
<td>Number of implants which never received a suprastructure due early implant loss (%)</td>
<td>35 (36%)</td>
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</table>

<table>
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<th>Suprastructures</th>
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<tbody>
<tr>
<td>Number of implants with single crowns (%)</td>
<td>118 (64%)</td>
</tr>
<tr>
<td>Number of implants with fixed prostheses (%)</td>
<td>61 (33%)</td>
</tr>
<tr>
<td>Number of implants which never received a suprastructure due early implant loss (%)</td>
<td>5 (3%)</td>
</tr>
</tbody>
</table>
from the bleeding index to Bleeding on Probing (BoP) had a score of 0 = BoP- and score 1,2 and 3 = BoP+ according to Meijer et al. [12]. The prevalence of peri-implant mucositis and peri-implantitis was calculated.

2.2.5. Patients & satisfaction and oral health related quality of life (OHQoL)

The patients were asked to complete questionnaires on:
- **Satisfaction**: Five questions focusing on masticatory ability, perceived aesthetics and speech, treatment process and treatment result (score 1 = extremely dissatisfied; score 10 = extremely satisfied).
- **Oral health related quality of life (OHQoL)**: A validated Dutch translation of the oral health impact profile questionnaire (Dutch OHIP-NL49, total score ranges from 0 to 196 in which a high score represents a low OHQoL. [13]).

2.2.6. Statistical analyses

Implant survival was calculated using the Kaplan Meier analyses with 95% confidence intervals (95%CI; IBM SPSS Statistics 22). Confidence intervals were added to the survival curve by computing and combining the survival function, upper confidence intervals and lower confidence intervals in an overlay scatterplot in SPSS. For patients and their general practitioners who could not be reached by any means, the data was censored to the last date for which their information was available. Regarding radiographic assessments, statistical analyses were performed on the bone augmentation subgroup. The satisfaction and OHIP-NL49 subgroup were analysed in relation to the number of agenetic teeth (≤10 versus >10). The Mann-Whitney U Test was used on both statistical subgroups and r was calculated to measure the effect size. An r of 0.1, 0.3 and 0.5 corresponds with a small, medium and large effect size, respectively (IBM SPSS Statistics 22).

3. Results

3.1. Patient selection and implant survival

Forty-one patients, 17 men and 24 women, with a median age of 20 (IQR [19;24]) years at implant placement, met the selection criteria (Fig. 1). A total of 258 implants were placed ≥10 years previously in these 41 patients in order to provide them with fixed prosthodontics.

A total of 29 implants were lost in 12 patients. Two patients lost all their implants (n = 11 implants). Eight implants (6 patients) were lost ≤1 year after placement. The median follow-up of all 258 implants was 12 years (IQR [10;16]; range 0–25 years). One patient still had two implants in situ after 25 years of follow-up. The 10-year cumulative implant survival of all 258 implants (n = 41 patients) was 89.1% (95%CI 85.2–93.0%; Fig. 2).

3.2. Clinical evaluation

The 39 patients with remaining implants installed ≥10 years previously were approached. Twenty-eight of them (12 male; 16 female) were willing to visit UMCG and were clinically and radiographically evaluated (for details see Table 1). Eleven patients did not participate for the following reasons: not reachable (n = 4); could not participate because of work (n = 2); travel distance (n = 1); medical reasons (n = 1); personal issues (n = 1); or unclear reasons (n = 2) (Fig. 1).

The median age of the remaining clinical evaluation group (n = 28) was 33 (IQR [31;39]). Four of them had ectodermal dysplasia (14.3%). The median number of agenetic teeth (third molars excluded) was 10 (IQR [8;14]). A total of 184 implants were placed ≥10 years previously at a median age of 20 (IQR [19;21]). Bone-augmentation was needed for 96 implants (52%), viz., with intra-oral bone (n = 31; 32%) or extra-oral bone (n = 65; 68%).

3.2.1. Clinical assessment

Of the total 184 implants, 21 implants were excluded from evaluation for the following reasons: fixed prosthodontics were replaced by removable prosthodontics (n = 7), implant was lost and replaced (n = 9) or implant was lost and not replaced (n = 5). Of the 14 lost implants, more implants were lost in the maxilla (n = 9) in comparison to the mandible (n = 5) and more implants were lost in regions were bone augmentation was performed (n = 10) in comparison to no-augmented regions (n = 4). The exclusion of the 21 implants resulted in a clinical evaluation of 163 implants with a median follow-up of 12 years [11;12]. Mean probing pocket depth was 2.5 ± 0.9 mm (Table 2).

Over the years, aftercare was needed in 20 of 28 patients and included reparation after porcelain chipping (23 suprastructures, 13 patients), reattachment of the suprastructure as a result of a loose screw or debonding (13 suprastructures, 10 patients) and replacement of the abutment due fracture (2 suprastructures, 2 patients). For 11 suprastructures (in 6 patients) reparation of the porcelain chipping/wear was not possible and the suprastructure had to be replaced by a new one. Another reason for replacement of a suprastructure was the need for adjusting the color (8 suprastructures, 4 patients). Finally, in one patient 5 single crowns had to be replaced due to a dental trauma. In 4 patients implants had been placed before the age of 18. These patients received the implants 20–25 years ago. In none of these patients, implants had moved to an infra-position at last follow up (＞20 years after implant placement).

3.2.2. Marginal bone loss

The same 21 implants were excluded from radiographic assessments for the reasons mentioned above, thus 163 implants were available for evaluation. The median ≤10 year peri-implant bone loss was 1.53 mm (IQR [0.77; 2.34]) (Table 2). Median peri-implant bone loss was higher for implants placed in augmented bone compared to those placed in regions without bone augmentation (median 1.96 mm (IQR [1.08;3.14]) versus 1.29 mm (IQR [0.38;1.91]), respectively; p < 0.001; Mann-Whitney U Test; Fig. 3). Peri-implant bone loss was higher for implants placed in augmented bone (p < 0.001; Mann-Whitney U Test; Fig. 3).

3.2.3. Peri-implant mucositis and peri-implantitis

Of the 163 implants that were both clinically and radiographically evaluated, 18.5% (n = 31) showed no signs of peri-implant mucositis or peri-implantitis (BoP = 0, < 2 mm radiographic bone loss). Peri-implant mucositis (BoP = 1, < 2 mm radiographic bone loss) was rather common (65.4%). Peri-implantitis (BoP = 1, ≥2 mm radiographic bone loss) was seen in 16.1% of the implants (Table 2).

3.2.4. Patients’ satisfaction and oral health related quality of life (OHQoL)

The mean patients’ satisfaction score was 8.3 ± 1.5 indicating that the patients were very satisfied. Of the five subscales, appearance scored lowest (mean 7.3 ± 1.6, Table 3). The mean OHIP-NL49 score was 32.6 ± 30.1 indicating an adequate OHQoL. Satisfaction and OHQoL were not associated with the number of agenetic teeth (≤10 versus >10, Table 3).

4. Discussion

Very limited information is available about the long-term prognosis of dental implants in patients with oligodontia, hence the main focus of the present study. The long-term survival, satisfaction and OHQoL results reveal that implant treatment is a predictable and satisfactory treatment modality for oligodontia. However, peri-implant mucositis and peri-implantitis are common and implant survival is lower than that seen in patients missing teeth for other reasons than oligodontia [14,15]. The higher prevalence of peri-implantitis is, in all probability, influenced by the frequent need for bone augmentation as marginal bone loss was, in our study, significantly higher in areas needing bone...
Peri-implant mucositis and peri-implantitis are common phenomena in non-oligodontia patients with dental implants, 30.7% and 9.6% respectively at implant level [4]. In a 3–5 year follow-up study of implants in oligodontia, peri-implantitis was observed in 8 of the 179 implants (4.5%), 3 of which required implant removal [16]. This prevalence (4.5%) is much lower than in our study and may be due to the rather short follow-up in the Zou et al. [16] study as peri-implantitis develops with time. Zou et al. [16] also applied a less strict and less commonly applied definition of peri-implantitis. In our study, peri-implant mucositis and peri-implantitis are higher in oligodontia patients than in the above-mentioned non-compromised patients. This is probably linked to the need for bone augmentation in oligodontia before implant placement as marginal bone loss is significantly higher in those areas [17,18]. These authors showed that augmented bone, especially vertical augmented bone (very necessary in oligodontia), is more susceptible to resorption than native bone [17] and thus might, at least partially, underlie the inherent higher risk of developing peri-implantitis [18]. Furthermore, adequate plaque removal can be more complicated in oligodontia as many teeth are often replaced with implants provided with crowns or comprehensive multiple-unit suprastructure. Cleansing such structures is time consuming and requires proper and specific skills. Despite the low plaque scores in this study, which can be a consequence of increased time reservation and motivation for plaque removal before a regular oral check-up, the prevalence of peri-implant mucositis was high which emphasizes that plaque removal was not always as good as during the investigational check-up. Plaque has been identified as a major risk factor for the development of peri-implantitis [19] and, moreover, patients with multiple implants (≥4) exhibit higher odds ratios for peri-implantitis [20].

The evaluation of the OHQoL and satisfaction have to be interpreted with caution as only 28 of the 41 patients were able to participate and...
the data of the other 13 patients could not be collected. As the participants were generally satisfied and reasons for not participating was not due dissatisfaction, we presume that the patients’ satisfaction is generally high. Besides, a floor effect was noticed for the subdomains ‘Social disability’ and ‘Handicap’ of the OHIP questionnaire. Unfortunately, a more appropriate condition specific questionnaire for adults with oligodontia is not available. Despite the floor effect, the OHIP scores can be compared with other studies applying a prosthetic treatment in patients with agenetic teeth.

The total mean OHIP score in our study was lower, which means a better OHQoL, compared to the OHIP score reported for untreated patients with ≥4 congenital absence teeth [7]. In patients with ≥1 agenetic teeth, the OHQoL is very favourable (low OHIP score) after treatment with tooth- or implant supported fixed dental prostheses [21,22]. The OHIP scores of those two studies are more favourable (better OHQoL) than our post-treatment OHIP score, but the longer follow-up of our study might, at least in part, contribute this discrepancy in OHQoL. E.g., peri-implant problems that might develop with time as well as wear of a superstructure might result in a lower satisfaction and OHQoL. The Dueled et al. [21] study agrees with our results, that OHQol, is independent of the number of agenetic teeth (<6 versus ≥6). Regarding patient satisfaction, our favourable long-term results match those of Finnema et al. [23], Stanford et al. [24] and Zou et al. [16] who reported favourable satisfaction too, though with short follow-up.

The major limitation of this study is the loss of follow-up of 13 of the 41 patients and this was inevitable due the retrospective design. Unfortunately, the resulting small study group limits statistical significance of the results. For subgroup analyses, larger groups are needed to assess which factors truly influences implants survival in oligodontia (e.g., augmentation versus no augmentation; maxilla versus mandible). Moreover, also the results of the subgroup analysis for OHQol and satisfaction (e.g., number of agenetic teeth) are limited by the small group numbers and have to be interpreted with caution.

In summary, although the treatment outcome is favourable and the patients are very satisfied, there seems to be a higher risk of complications after comparing peri-implant mucositis, peri-implantitis and implant loss in oligodontia patients with non-compromised patients. This is probably related to the frequent need for bone augmentation.

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Conflict of interest statement

No conflicts of interest are declared.

Contributors

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References


Table 3

Table 3 Mean (SD) satisfaction and OHIP-NL49 scores of clinical evaluation group (n = 28). For satisfaction a high score means a high satisfaction level. For OHIP-NL49 a high score represents a low OHQoL. No significant differences between number of agenetic teeth (≤ 10 versus > 10) was found (Mann-Whitney U Test). An r (effect size) of 0.1, 0.3 and 0.5 correspond with a small, medium and large effect size, respectively.

<table>
<thead>
<tr>
<th>Total (n = 28)</th>
<th>≤10 agenetic teeth (n = 16)</th>
<th>&gt; 10 agenetic teeth (n = 12)</th>
<th>p-value</th>
<th>Effect size (r)</th>
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<tbody>
<tr>
<td>Satisfaction</td>
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</tr>
<tr>
<td>Mastication</td>
<td>8.8 (1.2)</td>
<td>8.8 (1.3)</td>
<td>9.0 (1.0)</td>
<td>0.544</td>
</tr>
<tr>
<td>Appearance</td>
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<td>7.3 (1.6)</td>
<td>7.5 (1.6)</td>
<td>0.422</td>
</tr>
<tr>
<td>Speech</td>
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<td>9.3 (1.0)</td>
<td>8.8 (1.2)</td>
<td>0.394</td>
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<tr>
<td>Treatment process</td>
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<td>8.6 (1.5)</td>
<td>7.7 (1.9)</td>
<td>0.294</td>
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<td>Treatment result</td>
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<td>8.5 (1.2)</td>
<td>7.8 (1.9)</td>
<td>0.357</td>
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<td>OHIP-NL49</td>
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<tr>
<td>Functional limitation</td>
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<td>8.4 (6.3)</td>
<td>6.6 (4.5)</td>
<td>0.599</td>
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<td>Physical discomfort</td>
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<td>8.8 (6.2)</td>
<td>6.7 (4.9)</td>
<td>0.423</td>
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<td>Psychological discomfort</td>
<td>6.0 (6.5)</td>
<td>5.8 (6.9)</td>
<td>6.4 (6.2)</td>
<td>0.507</td>
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<td>4.7 (4.4)</td>
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<td>3.4 (5.2)</td>
<td>2.7 (4.9)</td>
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<tr>
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<td>1.6 (3.1)</td>
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<td>Handicap</td>
<td>1.6 (2.8)</td>
<td>1.9 (3.1)</td>
<td>1.3 (2.4)</td>
<td>0.732</td>
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<td>35.1 (33.7)</td>
<td>29.3 (25.6)</td>
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