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ORIGINAL ARTICLE

# Effect of the aetiology and severity of liver disease on oral health and dental treatment prior to transplantation

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## Summary

Elimination of dental infection foci has been recommended before liver transplantation (LT) because lifelong immunosuppression may predispose to infection spread. Association between pre-LT oral health and the aetiology and severity of chronic liver disease (CLD) was investigated retrospectively. A total of 212 adult patients (median age 51.1) who had received LT during 2000–2006 in Finland were included. Their oral health had been pre-operatively examined. Patients were divided into seven different CLD groups. Common indications for LT were primary sclerosing cholangitis (PSC 25.5%), alcohol cirrhosis (ALCI 17.5%) and primary biliary cirrhosis (PBC 14.6%). Patients were also categorized by the Model for End stage Liver Disease (MELD) scoring system. Medical, dental and panoramic jaw x-ray data were analysed between groups. PBC patients had the lowest number of teeth with significant difference to PSC patients (19.7 vs. 25.6, $P < 0.005$, ANOVA, $t$-test). ALCI patients had the highest number of tooth extractions with significant difference in comparison to PSC patients (5.6 vs. 2.5, $P < 0.005$). Lower MELD score resulted in fewer tooth extractions but after adjusting for several confounding factors, age was the most important factor associated with extractions ($P < 0.005$). The aetiology of CLD associated with the oral health status and there was a tendency towards worse dental health with higher MELD scores.

## Introduction

Immunosuppression may predispose to infections after liver transplantation (LT). An oral examination has been a prerequisite prior to LT in many centres and its purpose is the elimination of oral infection foci and hence the prevention of sepsis of oral origin [1–7]. By definition, a focal infection is a localized or generalized infection caused by the dissemination of microorganisms or toxic products from a focus of infection in various organic districts, including the oral district.

Scientific evidence is lacking regarding the benefits from the optimal dental management of the candidate for transplantation in relation to the outcome of LT (1). Nevertheless, dental infections have been a reason for a cancellation or postponement of the transplantation surgery [2] and thus a routine pretransplantation dental screening examination is empirically suggested. Since infections are a major cause for mortality among immunosuppressed post-LT patients [8], careful oral examination and eradication of all potential dental foci aim to reduce bacteraemia and eventually morbidity.

Several studies have shown an association between dental infections and general health although a direct causative relationship has not been established [9]. Infection of the teeth and inflamed periodontal tissues spread when oral pathogens and their toxins are released directly to the blood stream. Oral infections, especially periodontitis,

have been found to be a risk factor for several systemic diseases such as diabetes mellitus, cardiovascular disease, respiratory disease and preterm pregnancy with low birth weight [10]. Systemic conditions together with medications affect salivary flow rate which decreases when the number of drugs used daily increases [11]. Hyposalivation affects the susceptibility for oral diseases. Furthermore, cholestatic liver disease may affect bone structure and thus have detrimental effects also on the teeth and jaws. Chronic liver disease (CLD), may thus have harmful effects on the oral cavity by several pathological mechanisms.

Data are sparse of the oral health and dental management of LT patients, and however, there are no uniform pretransplant guidelines given for the oral health treatment choices (1). Therefore, the aim of our present study was to investigate oral health among LT patients of different aetiologies before accepting them to the transplant waiting list during evaluation for LT. The study was based on medical and dental records of the patients. Special emphasis was focused on oral infections and the mode of dental treatment given before LT. Differences were studied in oral health status depending on the aetiology of the CLD and we also hypothesized that severe liver disease associates with poor oral health.

## Patients and methods

All adult patients who had received LT during 2000–2006 at the Helsinki University Central Hospital (HUCH), Finland, and who had had a dental examination during evaluation process before listing for LT, were enrolled in this study. The study population consisted of 212 patients, 121 men and 91 women, who represent 74.1% of all LT (286) and 82.5% of all adult LT (257) patients during those years. Acute and sub-acute liver disease patients were excluded since in most of these cases the medical condition did not allow dental examination before listing for emergency LT. Median age at the time of LT was 51.1 years ranging from 15.3 to 74.1. The patients' medications, other systemic diseases such as diabetes and dialysis treatment, as well as oral health data at the time of listing, were recorded from the medical and dental files.

In our hospital the evaluation for LT includes dental examination by an experienced specialist in hospital dentistry. The hard and soft oral tissues are being examined and signs of oral infections are recorded. Panoramic jaw and tooth x-rays of the patients with a written statement of a radiologist is available to help clinical diagnosis. Infectious dental foci include apical periodontitis (apical radiolucencies) as seen in the x-rays, periodontitis which is recorded as ≥6 mm periodontal pocket depths and severe alveolar bone tooth attachment loss (ABL, measured in mm from the cemento-enamel junction of the tooth to the horizontal bone crest of the jaw), non-vital teeth with deep caries cavities, root remnants and partially erupted wisdom teeth with pericoronitis. Mucosal pathologies including e.g. aphtous lesions, stomatitis, oral candidiasis, or leukoplakias are also recorded. Furthermore, possible temporomandibular disorders such as clicking of the joint, restrictions of the mouth opening, or radiological findings of arthrosis are recorded.

The HUCH policy has been that all potential infectious foci are eliminated by extracting the teeth with obvious signs of infections. Tooth extractions are done in an operating room and conducted usually under intravenous sedation. Antibiotic prophylaxis is administered to prevent infections. The typical antibiotic regimen includes 2 g amoxicillin + 500 mg metronidazole, or 600 mg clindamycin for patients with penicillin allergy. When appropriate, coagulating agents (fresh frozen plasma and platelets) and cyclocapron are given preoperatively to prevent excessive bleeding if the platelet count is <50 and INR>3. Oral wounds are carefully sutured and tight dressing saturated with cyclocapron is placed in the tooth socket to ensure proper haemostasis. Caries cavities are either filled temporarily or restored permanently depending on the patient's medical condition. Mucosal disorders are treated. Dental calculus is removed and maintaining daily oral hygiene is emphasized by counselling the patients for proper home care. For the present study the number of teeth was calculated from panoramic x-rays. Edentulous patients were excluded when recording the number of infectious dental foci.

The patients were classified into different groups based on the following type of CLD: primary sclerosing cholangitis (PSC), primary biliary cirrhosis (PBC), alcohol cirrhosis (ALCI), cryptogenic cirrhosis (CRYPT), other cirrhosis (OTCI; including autoimmune cirrhosis and viral hepatitis), malignant primary liver tumours (MALIGN) and other liver diseases (OTHER; e.g. biliary atresia and metabolic liver diseases).

Chronic liver disease patients were also categorized according to the severity of the liver disease using the model for end stage liver disease (MELD) scoring system [12]. The MELD score has been validated in different patient groups with end stage liver disease and because this score predicts the risk to die and the severity of the liver disease, USA along with some other countries use it for allocation for LT. In Finland the MELD score is not used for allocation since we only have one centre for LT and median waiting time is short, about 40 days. Nevertheless, the MELD score in the present study was calculated using the Mayo clinic calculator with the blood creatinine, bilirubin and INR values recorded at the time of listing for LT. MELD scores were divided into three

groups: low (MELD <10), medium (MELD 11–18) and high (MELD 19–40). For the patients on dialysis creatinine value was set to be 350 μmol/l and conversion factors for units from μmol/l to mg/dl were used for both creatinine and bilirubin.

One-way ANOVA was used to analyse differences in means between the CLD groups, and Student's *t*-test and Mann–Whitney *U*-test for nonparametric variables were used to test the statistical significance between the CLD and MELD score groups. A uni- and multivariate logistic regression analysis was performed to study the risk factors associated with worse oral health. The need for tooth extraction (if only wisdom tooth was extracted, then it was regarded as 'no extractions') was used as a dependent variable and all the other variables analysed (age, gender, aetiology of liver disease, type of medications, diabetes) were considered as independent variables. The significance was set at 0.05 in all tests with 95% confidence intervals (CI). The statistical software used was the PASW version 17.0 (Statistical Package for the Social Sciences, Chicago, IL, USA).

## Results

Basic characteristics of the patients as recorded before the transplantation are given in Table 1. PSC was the largest liver disease group (25.5%), followed by ALCI (17.5%), and PBC (14.6%), respectively. The ALCI group included significantly more men than women when compared with those in the PBC group (78.4% vs. 19.4%; CI: 0.4–0.8, $P < 0.001$). Differences existed also with regard to age. The patients in the OTHER group were significantly younger than all the other patients in other groups – e.g. difference between PBC and OTHER (55.8 vs. 32.6 years [median], CI: 0.0–0.0, $P < 0.005$). Use of cardiovascular and metabolic medications was common among the patients. Cardiovascular medications included diuretics which together with a non-selective ß-blocker were mainly used to treat portal hypertension complications like ascites, or as prophylaxis for variceal bleeding. Almost all the patients in CRYPT group had cardiovascular medication and there was a difference in prevalence when compared with the PSC patients (92.9% vs. 40.7%; CI: 0.0–1.0, $P = 0.058$). Every third PBC patient had used psychiatric medication before LT. With respect to median MELD scores, a significant difference was found between CRYPT and PSC (22 vs. 6; CI: 0.0–0.0, $P < 0.001$) and also between ALCI and PSC groups (20 vs. 6; CI: 0.0–0.0, $P < 0.001$).

Eight patients were on dialysis before LT. The length of dialysis was <3 months (range 8–72 days) before transplantation for five patients, and only three patients were on dialysis for a longer period of time (108, 271, and 312 days). As these dialysis patients were so few, we decided not to exclude them from the analysis.

Oral health data of the patients are given in Table 1. Mean number of teeth was 23.4 in all patients with 11 patients (5.2%) being edentulous. However, significant differences were observed in the number of teeth between the different CLD groups. PBC patients had the lowest number of teeth and there was a significant difference when compared with PSC (19.7 vs. 25.6; CI: 2.6–9.2, $P < 0.005$). CRYPT patients showed significantly more alveolar bone loss than that in patients in the OTHER group (4.3 vs. 1.5; CI: 0.1–5.6, $P < 0.05$). Mucosal pathologies were prevalent and the most common abnormality was stomatitis (redness and swelling of the oral mucosa), recorded in 20 patients. In most cases ill-fitting dental prostheses and dry mouth were associated with stomatitis. Six patients had leukoplakias (white, patchy lesions).

Of all patients, 62.7% required tooth extractions and 3.3 teeth on average had been extracted immediately prior to LT as a result of the dental examination. The most common reason for extractions was dental caries (apical periodontitis, deep caries cavity, or root remnant) in all groups except in the OTHER group where partially erupted or impacted wisdom teeth were the typical reason for extractions. Two patients in the cohort underwent apicoectomies to treat apical periodontitis whereas all the other teeth with apical periodontitis were extracted. The second most common reason for extractions was periodontitis. Fourteen patients (6.6%) showed complications following tooth extractions. Excessive bleeding requiring hospital treatment was the most typical complication; there were also a few cases of fewer, swelling, sinus perforations and haematoma. In general, ALCI patients had the highest number of dental infection foci recorded and the difference was significant between ALCI and PSC patients (5.7 vs. 2.5; CI: 1.2–5.1, $P < 0.005$). The number and type of dental infection foci recorded from the different patient groups are shown in detail in Fig. 1. A panoramic x-ray of an ALCI patient clarifies the different dental infectious foci in Fig. 2.

Chronic liver disease patients with a higher MELD score associated significantly with older age (50.7 vs. 46.5; CI: 0.4–8.1, $P < 0.05$), fewer number of teeth (21.2 vs. 25.3; CI: 1.4–6.7, $P < 0.005$) and more frequent tooth extractions (4.8 vs. 2.0; CI: 1.6–4.2, $P < 0.005$) when the middle MELD score group was compared to the low MELD score group. Significantly more tooth extractions were also found between high and low MELD groups (3.4 vs. 2.0; CI: 0.4–2.6, $P < 0.05$) but not between the high and medium MELD groups since the most frequent tooth extractions were observed in the middle MELD score group. Alveolar bone loss was more pronounced in the middle MELD group than in the low MELD group

**Table 1.** Basic characteristics of the 212 patients at listing. The percentages are calculated within disease groups.

| | | PSC | PBC | ALCI | CRYPT | OTCI | MALIGN | OTHER | ALL |
|---|---|---|---|---|---|---|---|---|---|
| | | *n* = 54 | *n* = 31 | *n* = 37 | *n* = 14 | *n* = 33 | *n* = 24 | *n* = 19 | *n* = 212 |
| All | *n* (% of all) | 54 (25.5) | 31 (14.6) | 37 (17.5) | 14 (6.6) | 33 (15.6) | 24 (11.3) | 19 (9.0) | 212 (100) |
| Men | *n* (%) | 36 (66.7) | 6 (19.4) | **29 (78.4)**† | 8 (57.1) | 19 (57.6) | 17 (70.8) | 6 (31.6) | 121 (57.1) |
| Women | *n* (%) | 18 (33.3) | 25 (80.6) | 8 (21.6) | 6 (42.9) | 14 (42.4) | 7 (29.2) | 13 (68.4) | 91 (42.9) |
| Age | Median (range) | 45.6 (24–62.2) | 55.8 (35.9–66.8) | 54.2 (35.4–66.2) | 56.6 (18.6–66.9) | 44.8 (21.2–73.3) | 54.3 (16.8–74.1) | **32.6 (15.3–66.5)**‡ | 51.1 (15.3–74.1) |
| Type 1 diabetes | *n* (%) | 1 (1.9) | 0 (0) | 0 (0) | 0 (0) | 1 (3.0) | 2 (8.3) | 0 (0) | 4 (1.9) |
| Type 2 diabetes | *n* (%) | 2 (3.7) | 4 (12.9) | 9 (24.3) | 5 (35.7) | 7 (21.2) | 7 (29.2) | 2 (10.5) | 36 (17.0) |
| Dialysis | *n* (%) | 0 (0) | 1 (3.2) | 2 (5.4) | 3 (21.4) | 1 (3.0) | 0 (0) | 1 (5.3) | 8 (3.8) |
| Medication | | | | | | | | | |
| Gastrointestinal | *n* (%) | 51 (94.4) | 27 (87.1) | 26 (70.3) | 12 (85.7) | 26 (78.8) | 11 (45.8) | 14 (73.7) | 167 (78.8) |
| Cardiovascular | *n* (%) | 22 (40.7) | 22 (71.0) | 28 (75.7) | **13 (92.9)**§ | 27 (81.8) | 16 (66.7) | 13 (68.4) | 141 (66.5) |
| Metabolic | *n* (%) | 15 (27.8) | 16 (51.6) | 11 (29.7) | 8 (57.1) | 18 (54.5) | 9 (37.5) | 7 (36.8) | 84 (39.6) |
| Antibiotics | *n* (%) | 18 (33.3) | 7 (22.6) | 19 (51.4) | 8 (57.1) | 13 (39.4) | 7 (29.2) | 7 (36.8) | 79 (37.3) |
| Vitamins | *n* (%) | 5 (9.3) | 13 (41.9) | 12 (32.4) | 4 (28.6) | 7 (21.2) | 2 (8.3) | 9 (47.4) | 52 (24.5) |
| Psychiatric | *n* (%) | 9 (16.7) | 9 (29.0) | 5 (13.5) | 3 (21.4) | 5 (15.2) | 1 (4.2) | 3 (15.8) | 35 (16.5) |
| MELD score | Median (range) | 6 (1–19) | 12 (6–28) | **20 (8–39)**¶ | **22 (13–40)**¶ | 15 (4–40) | 11 (1–33) | 14 (1–32) | 13 (1–40) |
| Oral health status | | | | | | | | | |
| No. of teeth | Mean (±SD) | 25.6 (4.8) | **19.7 (10.1)**** | 21.6 (10.1) | 21.1 (10.4) | 24.9 (5.3) | 22.3 (7.9) | 26.8 (7.8) | 23.4 (8.2) |
| No. of teeth to be filled | Mean (±SD) | 2.3 (2.9) | 2.7 (3.0) | 2.1 (2.2) | 1.0 (1.4) | 2.9 (3.0) | 3.2 (3.5) | 2.6 (2.9) | 2.5 (2.9) |
| Attrition | *n* (%) | 6 (11.1) | 6 (19.4) | 9 (24.3) | 1 (7.1) | 3 (9.1) | 5 (20.8) | 2 (10.5) | 32 (15.1) |
| Erosion | *n* (%) | 2 (3.7) | 2 (6.5) | 4 (10.8) | 0 (0) | 1 (3.0) | 3 (12.5) | 0 (0) | 12 (5.7) |
| Periodontal pockets | | | | | | | | | |
| ≥4 mm | Mean (±SD) | 9.4 (6.2) | 8.0 | 7.3 (10.5) | 3.0 | 8.6 (8.3) | 16.0 | 15.5 (0.7) | 9.2 (7.4) |
| ≥6 mm | Mean (±SD) | 4.5 (4.9) | 6.0 | 3.3 (0.6) | 8.0 | 4.8 (4.1) | 4.0 | 0 (0) | 4.7 (2.9) |
| ABL in mm | Mean (±SD) | 2.5 (2.0) | 2.6 (1.3) | 2.9 (1.0) | **4.3**†† | 3.1 (1.1) | 2.7 | 1.5 (0.6) | 2.7 (1.4) |
| Mucosal pathologies* | *n* (%) | 4 (7.4) | 9 (29.0) | 10 (27.0) | 4 (28.6) | 4 (12.1) | 7 (29.2) | 3 (15.8) | 41 (19.4) |
| Removable prostheses | *n* (%) | 5 (9.3) | 5 (16.1) | 4 (10.8) | 2 (14.3) | 5 (15.1) | 3 (12.5) | 0 (0) | 24 (11.3) |
| TMD | *n* (%) | 5 (9.3) | 2 (6.5) | 2 (5.4) | 2 (14.3) | 3 (9.1) | 2 (8.3) | 0 (0) | 16 (7.5) |

ABL, alveolar bone loss; ALCI, alcohol cirrhosis; CRYPT, cryptogenic cirrhosis; MALIGN, malignant liver disease; MELD, The model for end stage liver disease is a scoring system for assessing the severity of chronic liver disease. In the MELD formula highest serum creatinine value used was 350 μmol/l which was used also for dialysis patients; OTCI, other cirrhosis (incl. autoimmune cirrhosis and viral hepatitis); OTHER, other chronic liver diseases (incl. biliary atresia and metabolic liver diseases); PBC, primary biliary cirrhosis; PSC, primary sclerosing cholangitis; TMD, temporomandibular joint disorder = e.g. clicking sound of the joint, opening restrictions of the mouth or radiological finding of arthrosis.

*leukoplakia, aphtous ulcer, gingival or mucosal hyperplasia, angular cheilitis, stomatitis, yellow mucosa or hairy tongue.

†CI: 0.4–0.8, $P < 0.001$ between ALCI and PBC.

‡CI: 0.0–0.0, $P < 0.005$ between OTHER and PBC.

§CI: 0.0–1.0, $P = 0.058$ between CRYPT and PSC.

¶CI: 0.0–0.0, $P < 0.001$ between CRYPT vs. PSC and ALCI versus PSC.

**CI: 2.6–9.2, $P < 0.005$ between PBC and PSC.

††CI: 0.1-5.6, $P < 0.05$ between CRYPT and OTHER.

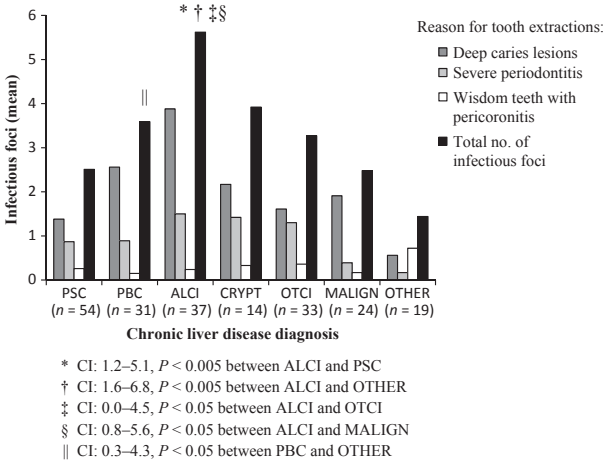



**Figure 1** Prevalence of dental infectious foci assessed to be in need for eradication before listing for LT.

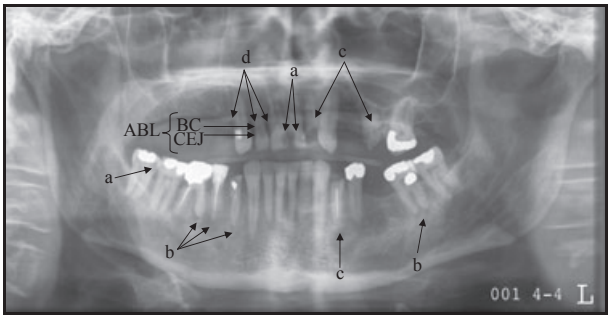


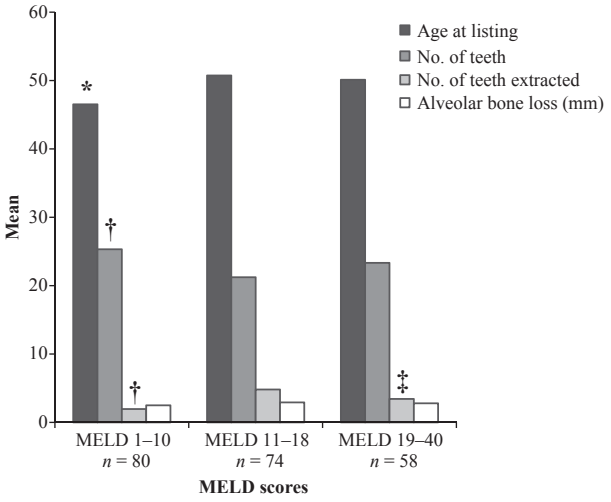

**Figure 2** Panoramic x-ray of a patient with alcohol cirrhosis. Sixteen teeth were extracted before liver transplantation. Infectious dental foci included: a = deep caries cavities, b = apical periodontitis, c = root remnants, and d = teeth with severe attachment loss. CEJ, cemento-enamel junction; BC, bone crest; ABL, alveolar bone loss which is measured as the distance between CEJ and BC.

(2.9 mm vs. 2.5 mm; CI: 0.3–1.2, $P = 0.272$) but that difference was not significant. Dental health data with respect to the MELD score are presented in Fig. 3.

Univariate logistic regression analysis showed that a lower MELD score protected significantly from the need of tooth extractions (OR = 0.68, CI: 0.48–0.96, $P < 0.05$). Certain aetiologies of CLD seemed to affect the need for tooth extractions but after adjusting for various confounding factors, age was the single most significant factor associated with extractions (OR = 0.96, CI: 0.93–0.98, $P < 0.005$) as seen in Table 2.

## Discussion

The results of the present study showed that CLD associated with oral health status in general and as we had postulated, there were major differences between the different liver disease groups in this respect. PBC and ALCI patients had worse oral health when compared with the other liver disease groups. Furthermore, patients with higher MELD scores presented poorer dental health than those with lower scores. The results thus confirmed our second study hypothesis.




* $P < 0.05$ between low (MELD 1–10) and middle (MELD 11–18) groups
† $P < 0.005$ -"- -"-
‡ $P < 0.05$ between high (MELD 19–40) and low (MELD 1–10) groups

**Figure 3** Dental health status of CLD patients in different MELD groups.

A PBC patient is typically a middle-aged woman [13] with possible sicca syndromes. Several studies have shown a correlation between PBC and Sjögren's syndrome, which is also of autoimmune origin [14–17]. Decreased salivary flow may indeed cause rapid tooth decay [18]. In addition to increased incidence for dental caries, patients suffering from hyposalivation are known to have also more gingival inflammation and fungal infections of the oral mucosa [19]. Eating, swallowing, talking and wearing dental prostheses become difficult in a dry mouth. LT patients commonly use several xerogenic medications that affect salivary flow rate. In a recent study, diuretic therapy was a significant risk factor for plaque-related gingivitis among LT candidates [3]. One-third of the PBC patients in our study used psychiatric medications and therefore stress or depression, and possible prolonged hyposalivation might be the factors that explain the lowest number of teeth in this group. However, no salivary data were available in the present retrospective investigation. Carious teeth were the most common reason for extractions in this group and in that respect, our results are in line with the study by Richards *et al.* [18].

**Table 2.** The odd ratios (OR) of the MELD score and the other factors on the occurrence of tooth extractions by univariate and multivariate logistic regression analysis. If only a wisdom tooth was extracted, then it was regarded as 'no extractions' in comparison to a patient with multiple extractions of infected dental foci.

| | Univariate analysis | | Multivariate analysis | |
|---|---|---|---|---|
| | OR (95% CI) | Sig. | OR (95% CI) | Sig. |
| MELD score | 0.68 (0.48–0.96) | **0.030** | 0.74 (0.48–1.14) | 0.168 |
| Aetiology of liver disease | | | | |
| Alcohol cirrhosis | 0.15 (0.04–0.51) | **0.002** | 0.28 (0.07–1.09) | 0.067 |
| Other cirrhosis | 0.30 (0.09–0.99) | **0.048** | 0.39 (0.11–1.44) | 0.159 |
| Diabetes | 1.16 (0.58–2.34) | 0.678 | 1.24 (0.56–2.76) | 0.601 |
| Cardiovascular medication | 1.61 (0.91–2.86) | 0.105 | 0.87 (0.44–1.73) | 0.698 |
| Psychiatric medication | 1.80 (0.83–3.90) | 0.136 | 0.57 (0.25–1.30) | 0.180 |
| Age | 1.10 (1.03–1.08) | **0.000** | 0.96 (0.93–0.98) | **0.002** |
| Gender | 0.73 (0.42–1.27) | 0.270 | 1.01 (0.53–1.91) | 0.987 |

The significant *P*-values are in bold.

Patients in the OTHER group, on the other hand, had the highest number of teeth and the lowest number of tooth extractions. The most frequent cause for tooth extractions was partially erupted or impacted wisdom teeth. This group included patients with metabolic diseases or biliary atresia who were the youngest patients in the total material; they were 23 years younger than the PBC patients. These OTHER-group patients also showed remarkably less alveolar bone loss than CRYPT patients further supporting the concept that age and the duration of CLD may have a detrimental effect on oral health. The findings from the multivariate analysis also showed that age was the single most important factor associated with the need for tooth extractions.

Primary Sclerosing Cholangitis patients had considerably higher number of teeth than PBC or ALCI patients. However, PSC patients were on average 10 years younger than PBC or ALCI patients which may partly explain the finding. PSC patients also had a lower MELD score than PBC patients indicating a better general health condition. The PSC group also included those who did not have an end stage liver insufficiency. The indication for their LT was serious recurrent cholangitis or progressive changes in the bile ducts with the suspicion of premalignant condition detected by brush cytology. We may also assume that the younger PSC patients had taken better care of their health including regular dental appointments. In Finland younger age groups have been entitled to partly state-reimbursed dental treatment which only recently has been extended to the whole population. Intervals >1 year since the last dental visit seem to increase the risk for dental disease in candidates for LT [3].

Alcohol use is known to deteriorate oral health in general [20,21]. In a previous study alcohol cirrhosis patients had the lowest number of teeth when compared with non-alcohol cirrhotic patients or with healthy controls [22]. The reason for worse oral health among alcohol cirrhotic patients in that study by Novacek *et al.* [22] was thought to be mainly attributable to poor oral hygiene and inadequate dental care. We might draw the same conclusions based on our present findings since we found a low number of teeth and the highest number of infectious dental foci indeed among the patients with alcohol cirrhosis during the evaluation process for LT.

A national survey from Finland in 10 000 individuals has shown that 30–64-year-old men and women have on average 24.1 number of teeth [23]. Both PBC and ALCI patients in the present study had thus remarkably lesser teeth than people in Finland in general. On the other hand, PSC patients had slightly more teeth on average than general population of the country further supporting the concept that they might be more health conscious than patients of the other liver disease groups.

Most authors in the field of organ transplantation agree that teeth with obvious infections, and all non-restorable teeth, must be extracted prior to transplantation even though the effect of the practice in preventing septic episodes remains controversial [24]. However, as said, there are no generally accepted guidelines as to how radical the eradication of dental infectious foci should be. Melkos *et al.* [6] suggested that dental treatment prior to organ transplantation does not have to be a radical one but they also showed, on the other hand, that more postoperative complications occurred in patients who did not get dental treatment prior to organ transplantation. Most of the patients in our study were referred to a dental examination often just few weeks before transplantation owing to short waiting time. Earlier dental interventions might result in fewer tooth extractions as also suggested by Rustemeyer *et al.* [7]. Therefore, patients should be

reminded of earlier dental treatment and the importance of good oral hygiene habits.

Although a definite association was not found between the MELD score and poor oral health, we might still postulate that our study showed a tendency towards worse dental health with higher MELD scores. Should a MELD score be used in the dental evaluation of LT candidates as a warning sign? The LT candidates whose MELD score was in the highest group had an end stage liver disease with many medical complications such as severe ascites, variceal bleeding, malnutrition and infections. Premedications, such as antibiotic prophylaxis and coagulating agents, as described earlier, aim to reduce the complications associated with the dental treatments of patients with a severe liver disease. These medically compromised patients are still at a very high risk for complications in connection with dental treatments [25–28]. Therefore, the dental surgeon should be aware of the MELD score when planning the extent of treatment.

The data presented herein are representative of the liver patients in Finland since our hospital is the centre for all LTs of the country. We studied 212 patients which number can be considered as a good sample size considering that approximately 50 LTs are annually made in Finland. The few previous studies published on this topic have also included other than LT patients in their research and the number of patients in these studies is smaller than in our present study [6,7]. Guggenheimer *et al.* [3] included 300 LT candidates but did not present oral health data based on the aetiology or severity of the liver disease.

In conclusion, in the present study CLD patients prior to LT had a high number of dental infection foci which needed treatment in particular if the patient had alcohol cirrhosis. The aetiology of CLD clearly associated with the oral health status and also the severity of the liver disease seemed to reflect in poor dental health. To our knowledge this is the first study taking the MELD score into account in this respect.

## Authorship

JHH: collected and analysed the data and wrote the paper. JHM, HI: designed and supervised the research and co-wrote the paper. KH, CL: helped to design the study and co-authored the paper.

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