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Identification and Differentiation of Highly Diverse Campylobacter concisus Strains using the MALDI Biotyper

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Abstract

In Danish diarrheic stool samples, the emerging enteric pathogen Campylobacter concisus has an incidence at the level of Campylobacter jejuni. Nevertheless, C. concisus has been neglected in many clinical laboratories due to labour intensive isolation procedures as well as time-consuming PCR-based methods for identification. Fourteen isolates of C. concisus were characterised in the MALDI-TOF mass spectrometer and analysed using the MALDI Biotyper and the ClinProTools 3.0 software. The data show that MALDI-TOF MS, as previously described for other Campylobacter species, can give a rapid identification of C. concisus. Interestingly, the isolates showed a remarkable diversity based upon their mass spectra when compared by visual and computational analysis.

Keywords: Campylobacter concisus; MALDI-TOF MS; Identification; Diversity; Campylobacter jejuni

In-vitro studies have shown that C. concisus is capable of invading intestinal epithelial cells, where it may increase apoptosis and the intestinal permeability [7,11,17]. These findings support the understanding of C. concisus as an intestinal pathogen. Campylobacter jejuni and other Campylobacter species can easily be identified to species level with use of matrix-assisted laser desorption/ionization time-of-flight mass spectrometry (MALDI-TOF MS) [2]. Campylobacter concisus does not grow on modified charcoal-cefoperazone-deoxycholate agar (mCCDA) which is routinely used for cultivation mCCDA in western countries. However, Campylobacter concisus and other emerging Campylobacter species can be isolated in high numbers in stools by use of a filtration technique on 5% yeast-enriched blood agar plates (SSI Diagnostica, Hillerod, Denmark) incubated at 37°C in a microaerobic atmosphere with hydrogen [14]. Identification of C. concisus has until recently been based on PCR-based techniques which may seem slow compared to the rapid identification by use of the MALDI-TOF MS. In this study, we evaluated MALDI-TOF MS as a method for the rapid identification of C. concisus.

Fourteen isolates of C. concisus were tested (Table 1). All isolates were cultured at Department of Clinical Microbiology, Aalborg University Hospital, Denmark. They consisted of seven faecal isolates from seven diarrheic patients. From three of these patients their oral isolate was also tested. Finally, three oral isolates from healthy individuals and the reference strain ATCC 33237 were investigated.

All isolates were primarily cultivated with use of the filter method as described elsewhere [14] and final reference identification was based on a species specific realtime PCR based on the chaperonin-60 gene and the 23S rRNA gene [1,3]. All isolates were stored at -80°C before being retrieved and sub-cultured on 5% horse blood agar plates, containing 1% yeast extract (SSI Diagnostica, Hillerod, Denmark) for 48 hours in a microaerobic atmosphere with hydrogen at 37°C before analysis.

For MALDI-TOF MS investigation, the extraction method used was according manufacturer's instructions and samples were measured in the MALDI-TOF mass spectrometer (MALDI Biotyper system, Bruker Daltonics). Acquired spectra were analysed using the MALDI Biotyper and the ClinProTools 2.2 software. A dendrogram

<table>
<thead>
<tr>
<th>Isolate number and source</th>
<th>Sex</th>
<th>Age</th>
<th>Clinical characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATCC 33237 Oral (Human gingival sulcus)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>K2 Oral</td>
<td>Female</td>
<td>25</td>
<td>Healthy</td>
</tr>
<tr>
<td>K4 Oral</td>
<td>Female</td>
<td>31</td>
<td>Healthy</td>
</tr>
<tr>
<td>M2 Oral</td>
<td>Male</td>
<td>26</td>
<td>Healthy</td>
</tr>
<tr>
<td>2009-74775 Faecal</td>
<td>Male</td>
<td>29</td>
<td>Crohn’s disease</td>
</tr>
<tr>
<td>2009-118452 Faecal</td>
<td>Female</td>
<td>19</td>
<td>Crohn’s disease</td>
</tr>
<tr>
<td>2009-119100 Faecal</td>
<td>Female</td>
<td>63</td>
<td>Collagenous colitis</td>
</tr>
<tr>
<td>2010-1718 Faecal</td>
<td>Female</td>
<td>2</td>
<td>Bloody diarrhoea</td>
</tr>
<tr>
<td>2010-112100 Oral+Faecal</td>
<td>Female</td>
<td>36</td>
<td>Crohn’s disease</td>
</tr>
<tr>
<td>2010-113332 Oral+Faecal</td>
<td>Female</td>
<td>57</td>
<td>Diarrhoea</td>
</tr>
<tr>
<td>2010-115605 Oral+Faecal</td>
<td>Male</td>
<td>42</td>
<td>Diarrhoea</td>
</tr>
</tbody>
</table>

Table 1: Campylobacter concisus isolates used in the study.

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of the MALDI-TOF profiles was constructed after main spectra (MSP) generation according to the recommendations of the manufacturer, and visual spectra comparison was performed. To assess the stability of the isolates, spectra after three re-cultivation steps, each for 48 hours, were analyzed. Furthermore, daily spectra from all isolates up to one week (after 24 hr, 48 hr, 72 hr, 96 hr, 120 hr, 144 hr and 168 hr) of incubation on the same agar plates were compared.

The fourteen isolates showed very high diversity with no real significant grouping. To investigate if MALDI-TOF MS could be used for a fast and reliable identification of *C. concisus* we evaluated the main spectra (20 per sample) of the 14 isolates and made a comparison with the MALDI Biotyper library containing four main spectra of bacterial strains. In spite of evident differences between the isolates, all strains were correctly identified as *C. concisus*, with scores over the threshold (log score 2.0) for secure species identification.

To test for the relationship to other closely related *Campylobacter* species, like *C. jejuni* and *C. coli*, their spectra were compared with the spectra of the different *C. concisus* isolates, and there was a clear separation between *C. concisus* and other *Campylobacter* species, when grouped together in a MSP dendrogram, indicating there is sufficient conserved peaks for species identification (Figure 1). However, two groups could be slightly separated by principle component analysis (not shown) as well as in a MSP dendrogram (Figure 2), although inside these groups variability was also very high. The variability of strain profiles was also confirmed by correlation analysis. The three coupled

![MSP Dendrogram](image1)

**Figure 1:** Example of a clear separation of strains of *Campylobacter concisus* and *Campylobacter coli* depicted by MSP dendrogram.

![MSP Dendrogram](image2)

**Figure 2:** Clustering of *Campylobacter concisus* strains in two groups depicted by MSP dendrogram. Inside both groups, considerable divergence can be observed.
sets of oral and faecal strains were also clearly different strains, and detailed visual spectra analysis revealed a unique profile for each strain. Investigation of spectra which previously have been used to construct the MSP in the bruker database also confirmed high intraspecies diversity. Finally, all isolates were very stable as they showed no change in the analysis after the three re-cultivation steps, or after one week of incubation (not shown).

The introduction of MALDI-TOF mass spectrometry into the routine laboratory has significantly improved the possibilities of a highly accurate identification of Campylobacter species, saving time and cost compared to conventional methods [2]. Nevertheless, C. concisus, a highly prevalent species in routine diarrheic stools, has been neglected in many clinical laboratories due to isolation procedures that use a labour intensive filter technique. Our data show that MALDI-TOF MS, as previously described for other Campylobacter species, can give a rapid identification of C. concisus. Interestingly, the isolates of C. concisus showed a remarkable diversity based upon their mass spectra when compared against each other by visual and computational analysis. In agreement with earlier reports [4,8,9], the intra-species diversity of C. concisus seems to be very high. This may be due to the oral nature of this species. Therefore, regarding genetic diversity the bacterium can be compared to the closely related Helicobacter pylori [6], but in contrast to H. pylori, the mass spectra of C. concisus strains still contain a significantly higher number of conserved peaks. This enables identification of the species with only a few database entries which cover the spectral diversity while a much higher number is necessary for coverage of H. pylori diversity. On the other hand, the very high intra-species diversity might facilitate epidemiological studies and strain tracking of C. concisus. Quite recently, Zautner et al., showed that MALDI-TOF MS could be used to discriminate specific subtypes of C. jejuni with different clinical relevance [18]. Similarly, we suggest that MALDI-TOF might play a useful role in subtyping of C. concisus. This information may prove essential for clinicians since C. concisus has been linked to different clinical manifestations like Crohn’s disease, chronic and acute gastroenteritis, and from healthy individuals. The clear difference in spectra between oral and faecal isolates from the same individuals suggests that intestinal disease is not necessarily caused by endogenous oral strains but possibly by transmission of intestinal-type pathogenic strains. Consequently, further studies are needed to investigate a larger cohort of different isolates with differences in the clinical severity. In conclusion, we advocate for culture and MALDI-TOF MS identification of C. concisus in diarrheic stool samples. Culture of C. concisus has the advantage of antibiotic susceptibility surveillance as well as epidemiological investigation in which MALDI-TOF may be used. Future studies are needed to evaluate the exact role of MALDI-TOF MS including more isolates to fully clarify the diversity and strains tracking within C. concisus.

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Part of this work was presented as a poster at European Congress of Clinical Microbiology and Infectious Diseases 2012, London, United Kingdom, March 31st - April 3rd. MK is an employee of Bruker Daltonics, the manufacturer of the MALDI-TOF MS system used in this study. The authors have no other funding to disclose.

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