Fecal microbiota transplantation outcomes in immunocompetent and immunocompromised patients: A single-center experience

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Abstract

Background: Clostridium difficile infection (CDI) is a major infectious disease focus for which fecal microbiota transplantation (FMT) has been used with success in various patient populations.

Methods: We conducted a retrospective study of FMT in immunocompetent and immunocompromised patients to review outcomes at our center, with a focus on identifying risk factors for FMT failure in solid organ transplant (SOT) patients. FMT was conducted using universal banked frozen stool via naso-duodenal tube in patients with recurrent CDI of 3 or more episodes per our institutional protocol.

Results: Thirteen patients were included in the analysis, 6 who were immunocompetent and 7 who were immunocompromised. Of these, 6 patients had a history of SOT and were primarily abdominal organ recipients. All immunocompetent patients experienced success with FMT, while 3 immunocompromised SOT patients experienced failure. Two patients who failed FMT had a second FMT, which was successful in one patient and failed in the second patient. No adverse events were noted with FMT administration. A predictor of FMT failure was antimicrobial exposure pre-FMT.

Conclusions: This study highlights the safe use of FMT for recurrent CDI with variable efficacy in immunocompromised patients. Antimicrobial exposure prior to FMT was an identified risk factor for FMT failure. The use of sequential FMT in SOT patients may be considered but ultimately requires further investigation.

KEYWORDS
Clostridium difficile infection, fecal microbiota transplantation, solid organ transplant

1 | INTRODUCTION

According to the Centers for Disease Control and Prevention, Clostridium difficile infection (CDI) caused half a million infections in the United States in 2011.1 CDI has become increasingly severe and has an inclination to recur in up to 20% of patients. It occurs as a result of disruption of normal intestinal microflora by antibiotics or other mechanisms, such as gastrointestinal (GI) surgery and chemotherapy. Additional CDI risk factors include age >64 years, duration of hospitalization, and antibiotic exposure.2 Of all risk factors, antibiotic exposure is the most modifiable.2,3

Current guidelines provide recommendations on effective medication management and the role of fecal microbiota transplantation (FMT).2,3 FMT involves transplantation of fecal microbiota from a healthy individual to a patient with CDI. The rationale is restoration of colonic microflora by infusing healthy bacterial flora and suppressing C. difficile. The ideal patient population(s) and timing for use of FMT are unclear; however, FMT has been recognized as another option in patients with multiple recurrences after exhausting standard anti-infective treatment options.

FMT has been effective in preventing CDI recurrences with mean success rates of 87%-90%.3 With such high success, FMT may be
beneficial for various immunocompromised patient populations, such as solid organ transplant (SOT), bone marrow transplant, and human immunodeficiency virus (HIV) patients. A theoretical concern exists for increased risk for infection from FMT owing to immunosuppression in these populations. Current literature substantiates the risk of infection from this procedure is minimal in the immunocompromised patient. Nonetheless, limited literature and guidance are available on FMT in SOT patients.

At our institution, we performed FMT for recurrent CDI in various patient populations, including SOT. Our protocol includes administering pre-screened, banked frozen stool to patients via naso-duodenal administration. We conducted a retrospective study to review outcomes of FMT in immunocompetent and immunocompromised patients. Our focus is to identify factors contributing to failure of FMT in the SOT population.

2 | MATERIALS AND METHODS

This was a retrospective study of immunocompetent and immunocompromised patients with recurrent CDI receiving FMT at Tampa General Hospital, a 1011-bed level-1 trauma center with affiliation to USF Health Morsani College of Medicine. The hospital performs various SOTs each year, including kidney, pancreas, liver, heart, and lung. This study was approved by our Institutional Review Board. Patients 18 years of age and older who received FMT for recurrent CDI from May 2014 through October 2015 were eligible for study inclusion. Patients were excluded if they received FMT for an indication other than recurrent CDI. An FMT protocol was developed by Infectious Diseases providers at our institution and approved by the Pharmacy and Therapeutics committee. Patients were eligible for FMT if they had a laboratory-confirmed diagnosis of recurrent CDI (3 or more episodes, defined as return of symptoms after completion of treatment), absence of neutropenia (absolute neutrophil count <500 cells/μL) and absence of toxic megacolon requiring emergent surgery. Consent was obtained from patients for FMT via naso-duodenal tube. This route of FMT administration was chosen as it was deemed easiest to facilitate among providers and nursing staff. In addition, Gastroenterology was not readily available to assist in administration of FMT via colonoscopy. Each FMT was performed using universal banked frozen stool obtained by OpenBiome (Medford, MA, USA). Pre-screening is performed by the company for transmissible infectious diseases prior to shipment of the product. This screening included complete blood count with differential, hepatitis panel (A, B, and C), hepatic function panel, HIV and human T-cell lymphotropic virus (HTLV)-I/II screening, syphilis testing, Helicobacter pylori stool antigen, stool cultures for enteric pathogens, stool ova and parasite, and stool C. difficile toxin. In addition, OpenBiome required prospective donors to undergo a 185-question clinical evaluation with an Internal Medicine specialist. Recipient preparation for FMT included bowel preparation the evening before FMT, dose of proton pump inhibitor (PPI) (pantoprazole 40 mg) given the evening prior and morning of FMT, and loperamide 4 mg given approximately 1 hour prior to FMT. Bowel preparation is not an absolute requirement for naso-duodenally administered FMT but was recommended for patients, if tolerated. All CDI-specific antimicrobials were stopped at least 24 hours before FMT; when possible, antibiotics were stopped 48-72 hours prior to FMT depending on the severity of illness of the patient. This time frame was adapted from previous literature and determined as the best approach for our center. It was recommended to stop or limit all other systemic antimicrobials prior to FMT, when possible, including prophylaxis for opportunistic infection. The naso-duodenal tube was placed with radiologic confirmation and removed after FMT. FMT product volume was 30 mL (28.5 g of product; 12.5 g of stool material) and diluted in normal saline (total volume approximately 100-150 mL) to aid in administration. Normal saline was used to flush all administered product through the tube to complete FMT. Patients were directly observed for 2 hours post FMT for any complaints of abdominal pain and/or discomfort. If stable, they were able to resume their previous diet. No specific diet or dietary restrictions were recommended post FMT. Patients were monitored for 24-48 hours post FMT, including vital signs, to assess for development of adverse events, abdominal pain/discomfort, or diarrhea. When possible, the patient was moved to a new room post FMT to minimize the risk for reinfection.

Pertinent baseline demographics, CDI, and FMT characteristics were collected for all patients. Patients were also reviewed for proximity of antimicrobial therapy to FMT and other pertinent microbiology testing during their admission. For SOT patients, the following information was collected: type and date of SOT, maintenance immunosuppression regimen, use of PPI prior to hospital admission, organ rejection within 3 months prior to FMT, and detection of cytomegalovirus within 3 months prior to FMT. Chart review was performed by two Infectious Diseases physicians (S.A., J.M.) to assess for FMT outcome and development of adverse events. Treatment success was defined as resolution of diarrhea based on stool consistency and frequency compared to patient’s baseline before CDI, along with improvement in associated signs and symptoms including abdominal pain and leukocytosis for 8 weeks. Treatment failure was defined as recurrence of diarrhea within 8 weeks post FMT after initial improvement and resolution of symptoms, along with associated signs, symptoms, and positive CDI testing in absence of a new diagnosis.

The study’s primary objective was to evaluate outcomes after FMT for recurrent CDI in immunocompetent and immunocompromised patients. Secondary objectives included identifying risk factors for failure of FMT in the SOT population. Traditional risk factors (antimicrobial use, PPI utilization) as well as other potential causes (immunosuppressive regimen, timing of FMT in relation to SOT) were investigated. Continuous data were analyzed using Mann-Whitney U test and are presented as median (interquartile range [IQR]), while categorical data were analyzed with Fisher’s exact test and are presented as percentages.

3 | RESULTS

Thirteen patients received FMT during the study period (Table 1). Seven (54%) were immunocompromised, of whom 6 were SOT...
recipients and 1 was HIV positive (CD4⁺ count=453 cells/mm³). No evidence of significant SOT rejection or opportunistic infection was seen within 1 year before FMT. In addition, no patients were being treated for active malignancy at the time of FMT. The remaining 6 patients were considered immunocompetent. The median age of patients in both groups was similar. Two patients were noted to have irritable bowel syndrome (IBS); no patients were previously diagnosed with Crohn’s disease or ulcerative colitis. All patients had recurrent CDI of 3 or more episodes during the 12 months before FMT.

All patients received oral vancomycin for treatment of CDI prior to FMT. Seven patients also received metronidazole before or in combination with oral vancomycin and 5 received fidaxomicin with or after oral vancomycin. The proximity of non-CDI antimicrobial therapy to FMT was evaluated in both study groups (Table 2). Significantly more patients in the immunocompromised group received an antimicrobial agent near the time of FMT compared to the immunocompetent group (6 patients vs 1 patient; P=.029). Antimicrobials were broken down by therapeutic and prophylactic use. More patients in the immunocompromised group received a therapeutic antimicrobial prior to FMT, although this difference was not statistically significant (4 patients vs 0 patients; P=.069). Prescribing patterns for antimicrobials in the immunocompromised group are shown in Table 3. In the immunocompetent group, one patient with a ventricular assist device (VAD) was prescribed amoxicillin/clavulanic acid to prevent infection secondary to nasal packing, which was present for epistaxis. The patient received antibiotics for 3 days, with the last dose given 5 days prior to FMT. In addition to antimicrobial therapy, the use of chronic PPI was evaluated prior to FMT and was noted in 7 patients with no difference between groups.

All patients had diarrhea as the main reason for obtaining C. difficile testing and all tested positive by polymerase chain reaction prior to FMT. Additional testing to confirm diagnosis of CDI was not performed. Ten patients reported associated abdominal pain. Bowel preparation for FMT with oral polyethylene glycol (GoLytely™) was used in 9 patients and all but 1 patient had antibiotics stopped 24-48 hours prior to FMT.

All patients had resolution or improvement of symptoms, most notably diarrhea, the day after FMT and remained diarrhea-free for 5 days post FMT; however, 3 patients relapsed thereafter (Table 3). All 3 patients were immunocompromised patients with a history of renal transplant on chronic immunosuppressive therapy who had antimicrobial exposure prior to initial FMT; they were re-admitted for severe

**TABLE 1** Demographics of fecal microbiota transplantation (FMT) population

<table>
<thead>
<tr>
<th>Demographics</th>
<th>Total population (n=13)</th>
<th>Immunocompetent (n=6)</th>
<th>Immunocompromised (n=7)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male, n (%)</td>
<td>5 (38.5)</td>
<td>2 (33.3)</td>
<td>3 (42.9)</td>
<td>1.00</td>
</tr>
<tr>
<td>Age, median (IQR)</td>
<td>69 (59, 74)</td>
<td>70.5 (49.5, 73.5)</td>
<td>69 (59, 72.5)</td>
<td>1.00</td>
</tr>
<tr>
<td>Diabetes, n (%)</td>
<td>3 (23.1)</td>
<td>1 (16.7)</td>
<td>2 (28.6)</td>
<td>1.00</td>
</tr>
<tr>
<td>Irritable bowel syndrome, n (%)</td>
<td>2 (15.4)</td>
<td>1 (16.7)</td>
<td>1 (14.3)</td>
<td>1.00</td>
</tr>
<tr>
<td>History of solid organ transplant, n (%)</td>
<td>6 (46.2)</td>
<td>0 (0)</td>
<td>6 (85.7)</td>
<td>.005</td>
</tr>
<tr>
<td>Number of CDI episodes prior to initial FMT, median (IQR)</td>
<td>4 (3, 4)</td>
<td>3.5 (3, 4)</td>
<td>4 (4, 4.5)</td>
<td>.345</td>
</tr>
</tbody>
</table>

IQR, interquartile range; CDI, Clostridium difficile infection.

**TABLE 2** Fecal microbiota transplantation (FMT) population data

<table>
<thead>
<tr>
<th>FMT data</th>
<th>Total population (n=13)</th>
<th>Immunocompetent (n=6)</th>
<th>Immunocompromised (n=7)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receipt of antimicrobials prior to FMT, n (%)</td>
<td>7 (53.8)</td>
<td>1 (16.7)</td>
<td>6 (85.7)</td>
<td>.029</td>
</tr>
<tr>
<td>Duration of non-CDI antimicrobials prior to FMT (days), median (IQR)³</td>
<td>3 (3, 3)</td>
<td>3 (3, 3)</td>
<td>3 (2.5, 4.25)</td>
<td>1.00</td>
</tr>
<tr>
<td>Proximity of non-CDI antimicrobials to FMT (days), median (IQR)</td>
<td>3 (2.5, 6)</td>
<td>5 (5, 5)</td>
<td>3 (2.25, 6)</td>
<td>.86</td>
</tr>
<tr>
<td>Therapeutic antimicrobials, n (%)</td>
<td>4 (30.8)</td>
<td>0 (0)</td>
<td>4 (57.1)</td>
<td>.069</td>
</tr>
<tr>
<td>Prophylactic antimicrobials, n (%)</td>
<td>3 (23.1)</td>
<td>1 (16.7)</td>
<td>2 (28.6)</td>
<td>1.00</td>
</tr>
<tr>
<td>PPI use prior to FMT, n (%)</td>
<td>7 (53.8)</td>
<td>3 (50)</td>
<td>4 (57.1)</td>
<td>1.00</td>
</tr>
<tr>
<td>Pre-FMT bowel prep given, n (%)</td>
<td>9 (69.2)</td>
<td>4 (66.7)</td>
<td>5 (71.4)</td>
<td>1.00</td>
</tr>
<tr>
<td>FMT failure, n (%)</td>
<td>3 (23.1)</td>
<td>0 (0)</td>
<td>3 (42.9)</td>
<td>.192</td>
</tr>
</tbody>
</table>

³These data do not consider patients who received trimethoprim/sulfamethoxazole (TMP/SMX) for Pneumocystis jirovecii pneumonia prophylaxis. CDI, Clostridium difficile infection; IQR, interquartile range; PPI, proton pump inhibitor.
CDI and considered FMT failures. Of these 3 patients, 2 received a second FMT. One patient was successful with no further episodes of CDI, and the second patient was considered a failure with recurrence 2 weeks post FMT. The remaining 10 patients continued to be symptom-free 8 weeks post FMT and to date and were considered successful. One kidney transplant received 2 doses of FMT on consecutive days in hopes of improving prevention of CDI recurrence and achieved success. No correlation was found between failure of FMT and immunosuppression agents (Table 4); however, significantly more patients who failed FMT received therapeutic antimicrobials prior to FMT (3 patients vs 1 patient; P = .014).

Patients in both groups received antimicrobials within 3 months post FMT. In the immunocompetent group, 3 patients received antimicrobials and all achieved success with FMT without experiencing CDI recurrence. Antibiotic use post FMT in the immunocompromised group is highlighted in Table 3. Only 1 patient received antimicrobials post FMT; this patient has not experienced recurrent CDI to date.

When stratifying success and failure in SOT patients, we found no significant differences between groups, including baseline demographics, PPI use, or immunosuppressive therapy. While not statistically different, the median time from organ transplant to FMT was 26 years among patients who failed FMT, compared to 7 years in patients who experienced FMT success (P = .10). In addition, we noted that the 3 SOT patients who failed FMT received therapeutic antimicrobials prior to FMT; however, only 1 SOT patient who experienced success received therapeutic antimicrobials before FMT.

No apparent complications of FMT occurred in our patient population. However, one patient experienced an episode of cytomegalovirus reactivation at the time of FMT and a mild episode of transplant rejection 2 months after FMT. This appeared unrelated to FMT and the patient did not experience CDI recurrence.

4 | DISCUSSION

Immunocompromised patients are at increased risk for CDI, especially SOT patients. SOT patients have a higher incidence of CDI owing to multiple and/or prolonged hospitalizations, antibiotic exposure, and significant immunosuppression during the initial months post transplantation.9 Pharmacotherapy management for CDI is the same for immunocompromised and immunocompetent patients.2,10 Once a patient experiences multiple relapses and has received standard pharmacotherapy, treatment becomes challenging; however, FMT presents a viable therapeutic option. Report of success with FMT in immunocompetent patients has been published and FMT remains a cornerstone for non-conventional treatment of recurrent CDI.3 FMT treatment has been limited in the immunocompromised population because of the theoretical risk of contracting infectious diseases or other complications.

Comparing our study groups, success of FMT differed between immunocompetent and immunocompromised patients, but with no statistical difference. All immunocompetent patients experienced CDI resolution within days after FMT. This group consisted of patients
who varied in age and those with VADs. The VAD population often develops infections requiring prolonged antibiotics. It was notable that these patients did well and have not experienced CDI recurrence. We also reviewed our immunocompetent patients for any history of underlying GI disorders, as intestinal dysbiosis is associated with CDI. We identified one patient with IBS who achieved FMT success. At the time of FMT, the patient was not experiencing an IBS episode and FMT was being used to treat CDI recurrence. Overall, our data coincides with current literature supporting the high efficacy of FMT in immunocompetent patients with recurrent CDI.

Conversely, our data noted failure in almost half of the immunocompromised group. Three patients failing FMT received kidney transplants. Diabetes mellitus has been noted as an independent risk factor for CDI recurrence, as it can impair host immunity and alter gut microbiota. However, we did not observe this to affect our patient population. We observed lower efficacy in SOT patients compared to current literature, which shows a success rate of 78% in immunocompromised patients receiving a single FMT. A larger study evaluated FMT in 19 SOT patients; however, the study authors did not provide details on which types of transplants the patients had received, average age of their patient population, cumulative duration of immunosuppression, as well as the presence of CDI risk factors. Thus, the reason is unclear for the difference in FMT success between our immunocompromised population and available literature, as we cannot directly compare our data. It is possible immune function may explain part of the difference. In our patients who failed FMT, the recurrent symptoms began within the first few weeks post FMT, suggesting that FMT failure may occur early post FMT.

Because of FMT failure in our immunocompromised group, we assessed potential risk factors, including antimicrobial exposure pre-and post FMT. Antimicrobial exposure is considered a predominant risk factor for initial CDI and recurrence owing to disruption of intestinal microflora. The majority of immunocompromised patients were receiving therapeutic antimicrobials before FMT. Interestingly, the 3 patients who failed FMT were exposed to beta-lactams or quinolones before FMT. This concurs with established literature showing exposure to fluoroquinolones and high-risk antibiotics, including cephalosporins, is significantly associated with CDI recurrence. One patient who failed FMT received the last antimicrobial dose on the day of FMT. It was noted that this patient deviated from our institutional protocol recommending that antimicrobials be stopped 48-72 hours prior to FMT, which may have ultimately impacted their FMT outcome. We also observed patients in both groups who received antibiotics within 3 months post FMT, but who did not experience CDI recurrence. It is unclear if antimicrobial exposure plays a more prominent role in FMT failure when given pre-FMT vs post FMT; however, we did find a difference in FMT success in patients who received therapeutic antimicrobials prior to FMT. Despite our small study, our data suggest that antimicrobial exposure pre-FMT influences CDI recurrence and impacts FMT outcomes.

Another potential risk factor for FMT failure was chronic PPI use. The implication of PPIs as a risk factor for initial CDI is debatable because of conflicting data. Thus, it is unclear if PPIs contribute to CDI recurrence or impact FMT outcome. It has been suggested that PPI use can affect stomach pH and interfere with the stomach’s defense against CDI. In our study, we noted chronic PPI use in both groups with no notable impact on CDI recurrence or FMT failure.

We investigated immunosuppressive regimens, type of organ transplant, and timing of FMT in relation to SOT. All SOT patients were receiving low-dose prednisone and the majority were receiving calcineurin inhibitor (CNI) therapy at the time of FMT. Patients who failed FMT included a kidney transplant recipient who was not on CNI therapy and did not have immunosuppression monitoring, one kidney transplant patient who achieved therapeutic immunosuppression, and a third kidney transplant who appeared somewhat subtherapeutically immunosuppressed at FMT. We did not establish any association between immunosuppressive agent and FMT failure, possibly owing to our small subset. Of note, the majority of SOT

TABLE 4  Fecal microbiota transplantation (FMT) success vs FMT failure

<table>
<thead>
<tr>
<th>Factors</th>
<th>FMT success (n=10)</th>
<th>FMT failure (n=3)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PPI use prior to FMT, n (%)</td>
<td>5 (50)</td>
<td>2 (66.7)</td>
<td>1.00</td>
</tr>
<tr>
<td>Receipt of antimicrobials prior to FMT, n (%)</td>
<td>4 (40)</td>
<td>3 (100)</td>
<td>.192</td>
</tr>
<tr>
<td>Therapeutic antimicrobials, n (%)</td>
<td>1 (10)</td>
<td>3 (100)</td>
<td>.014*</td>
</tr>
<tr>
<td>Prophylactic antimicrobials, n (%)</td>
<td>3 (30)</td>
<td>0 (0)</td>
<td>.528</td>
</tr>
<tr>
<td>Receipt of antimicrobials post FMT, n (%)</td>
<td>6 (60)</td>
<td>0 (0)</td>
<td>.192</td>
</tr>
<tr>
<td>Solid organ transplant patient, n (%)</td>
<td>3 (30)</td>
<td>3 (100)</td>
<td>.069</td>
</tr>
<tr>
<td>Receiving immunosuppression, n (%)</td>
<td>3 (30)</td>
<td>3 (100)</td>
<td>.069</td>
</tr>
<tr>
<td>Calcineurin inhibitors, n (%)</td>
<td>3 (30)</td>
<td>2 (66.7)</td>
<td>.511</td>
</tr>
<tr>
<td>Antiproliferative agents, n (%)</td>
<td>1 (10)</td>
<td>1 (33.3)</td>
<td>.432</td>
</tr>
<tr>
<td>Steroids, n (%)</td>
<td>3 (30)</td>
<td>3 (100)</td>
<td>.069</td>
</tr>
</tbody>
</table>

*Significant

PPI, proton pump inhibitor.
patients received an abdominal organ transplant. It is notable the patients who failed initial FMT had a history of renal transplant at least 15 years prior to FMT. It is possible that exposure to immunosuppressive agents over a prolonged period may disrupt GI flora, increasing the risk for CDI and FMT failure. In general, immunosuppressive agents can be associated with GI complications, including mucosal damage and ulceration, which may have occurred in these patients.

It was noted 2 of 3 patients who failed FMT were >64 years of age. As suggested by current guidelines, advanced age is an independent risk factor for CDI.5 The combination of prolonged immunosuppression, age, and antimicrobial exposure prior to FMT may have predisposed patients to FMT failure. In addition, their altered immunity may have resulted in lower levels of antibodies that normally protect from CDI.15,16 The role of immunity appears to be a significant factor, as suggested by differing FMT success between our immunocompetent and immunocompromised patients.

In one kidney transplant recipient, we performed sequential FMT to prevent failure; to date, this patient has not experienced CDI recurrence. Case reports have described successful use of sequential FMT in SOT patients.6 Sequential FMTs may remedy dysbiosis occurring in the GI tract with CDI.12,17 Other factors, such as antimicrobial exposure, use of CNIs and glucocorticoid steroids, can also affect intestinal flora, injure GI mucosa, and weaken the immune response to CDI.5,6,12,14 Sequential FMT may be a reasonable approach and a promising strategy in the SOT population, but requires further evaluation in larger studies.

At the time of this report, no adverse events or infectious disease complications were identified post FMT in our patients. It was noted that several patients experienced cramps and diarrhea from FMT, but these effects were transient. It does not appear the use of frozen donor stool contributes to significant adverse events.

Our study had limitations. First, this study was small, retrospective, and single-centered. Compared to larger studies of immunocompromised patients, those in our study were not noted to have medical conditions compromising FMT efficacy (ie, Crohn’s disease or ulcerative colitis) and we did not experience a high success rate in SOT patients.5 We acknowledge that no testing was performed to rule out additional enteric pathogens in the patients who failed FMT. Another limitation is lack of access to records for antimicrobials prescribed outside our institution. In addition, the numbers of SOT patients were small, with the majority involving abdominal transplants, which may be related to the higher volume of abdominal transplants performed annually at our institution. All but one SOT patient were >1 year post transplantation. As this was a retrospective review, we had limited data on immune and nutritional status. We also only utilized one route of FMT administration but acknowledge that other successful modalities are used by other centers. In addition, our study measured improvement based upon clinical evaluation post FMT and lacked a standardized measure of improvement because of inconsistent documentation in the medical record. Furthermore, other causes for diarrhea could not be excluded owing to limited documentation and patient workup.

In conclusion, FMT was highly successful in immunocompetent patients with variable efficacy in immunocompromised patients. FMT was safe and well-tolerated across our study population. Antimicrobial exposure before FMT was identified as a predictor for FMT failure. Age and prolonged immunosuppression may be important factors to consider, but would need to be evaluated in a larger study. The use of sequential FMT therapy in SOT patients may be considered to optimize restoration of intestinal microflora.

CONFLICTS OF INTEREST

The authors of this report have no conflicts of interest to disclose.

AUTHOR CONTRIBUTIONS

S.A., R.J., K.Z., and J.M: Concept/design of study, data collection, data analysis, drafting of article, revision, and approval of final article version.

REFERENCES


