비엔동물전문의료센터
BIEN ANIMAL MEDICAL CENTER

Fecal Microbiota Transplantation

FMT의 임상적 이해와 효과적 활용 전략

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Introduction

Dysbiosis

- The gut microbiota plays a vital role in digestion, immune modulation, and metabolism.
- An imbalance—known as **dysbiosis**—has been linked to various chronic conditions, including: Inflammatory bowel disease, obesity, diabetes, allergies

- **Cause**
  - Overuse of antibiotics
  - Lack of dietary diversity
  - Environmental factors
  - Genetic predisposition: Boston Terriers, Shih Tzus, French Bulldogs, German Shepherds, Bichon Frises
  - Medical interventions: H2 blocker, NSAIDs, Steroid

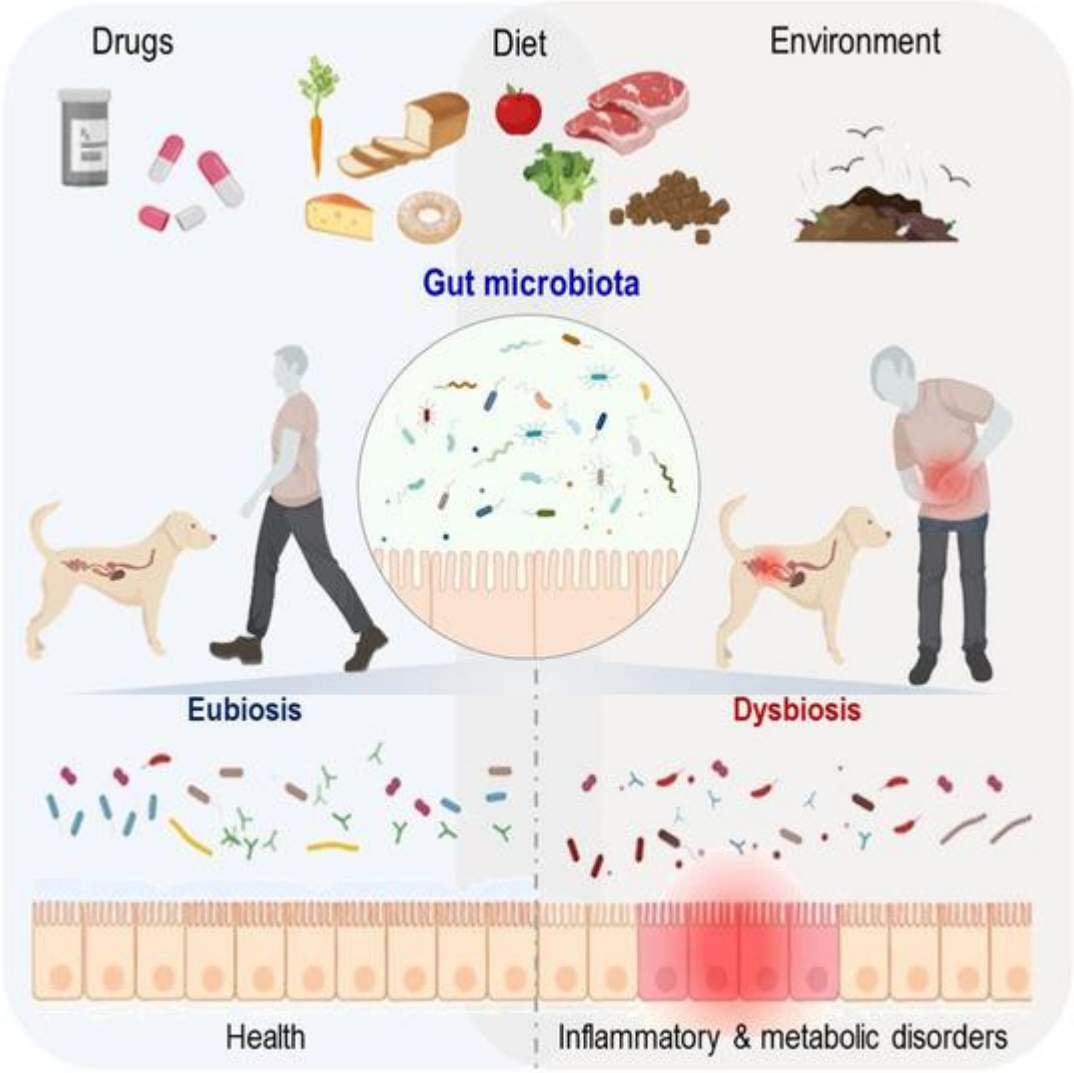


Figure 1. Overview of the impact of the domestic environment on the gut microbiota and health of humans and pet dogs.

Introduction

Clinical disorders associated with Dysbiosis

- Gastrointestinal disorders
  : Chronic diarrhea, IBD, Food intolerance
  : Dysbiosis can alter mucosal immunity, impair digestion, and trigger chronic inflammation in the gut
- Atopic dermatitis: Gut-skin axis
- Liver disease: Gut-liver axis
- Chronic kidney disease: Gut-kidney axis
- Pancreatitis
- Neurological disorders: Gut-brain axis
- Neoplasia

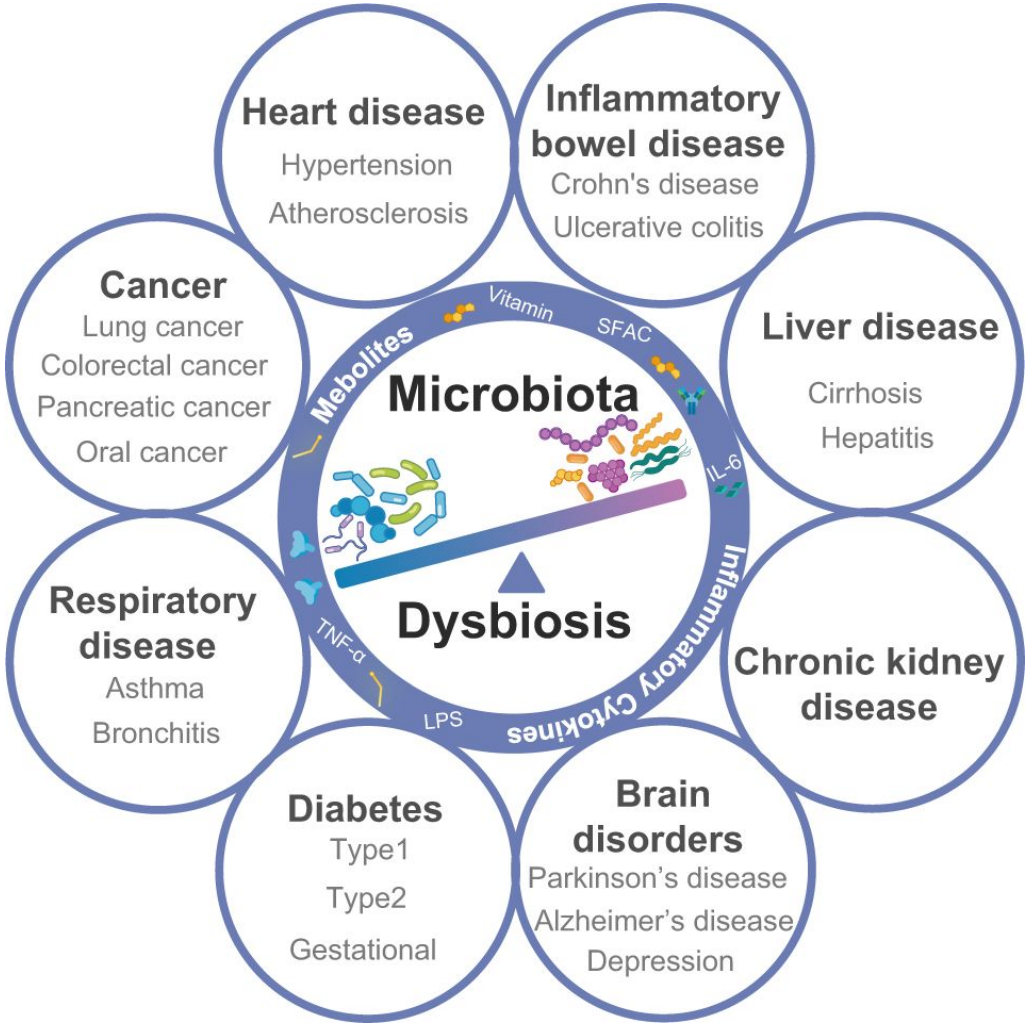


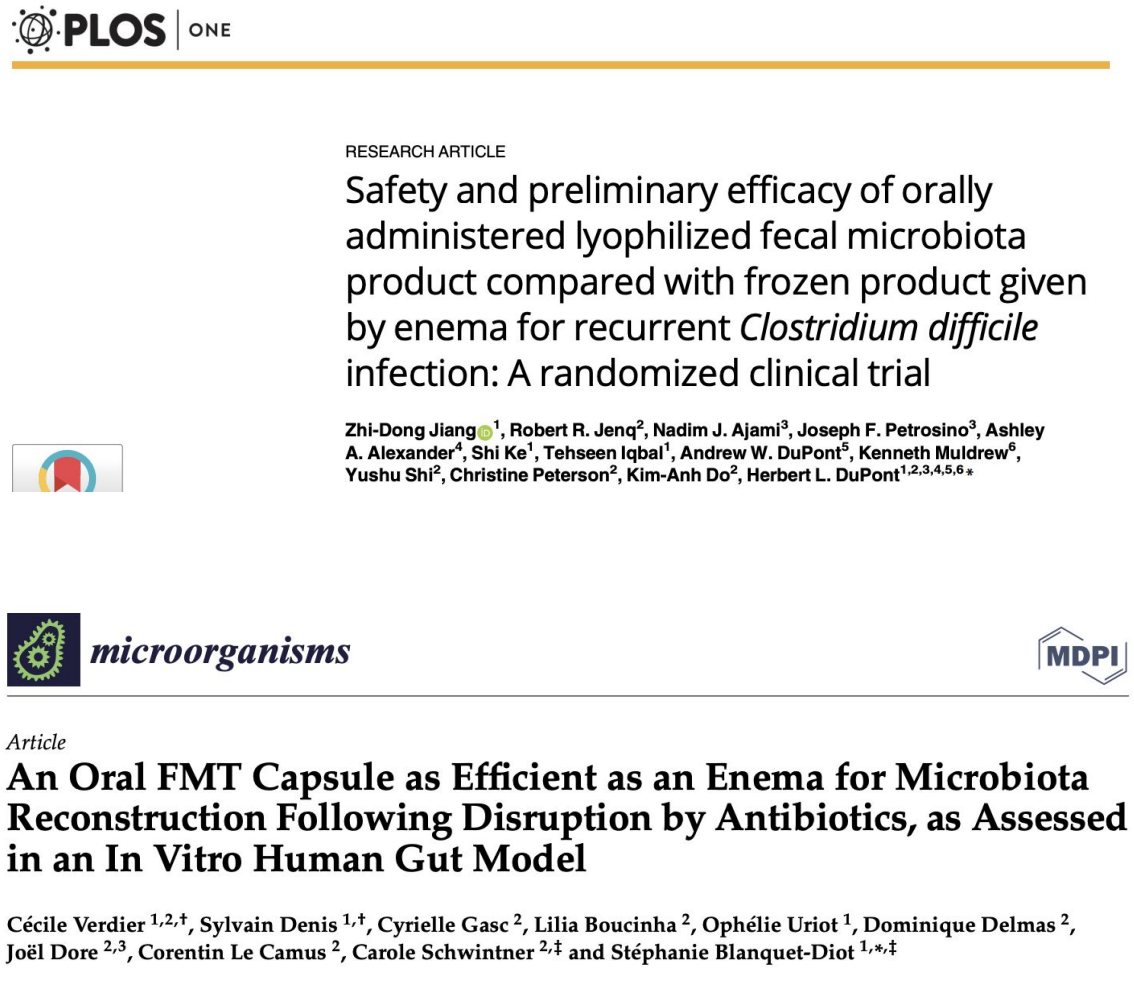
Figure 2. Human microbiota dysbiosis contributes to various diseases

Introduction

FMT, Fecal Microbiota Transplantation

- A therapeutic procedure where feces from a healthy donor dog or cat—rigorously tested for **safety (PCR)** and **efficacy (NGS)**—are transplanted into patients with gut microbiota imbalance.
- Helps **regulate immune and inflammatory responses**, improving clinical symptoms.

- **Administration routes**
  - **Oral capsules**: easy and non-invasive, no anesthesia required
  - **Rectal infusion**: liquid transplant delivered via the rectum



PLOS ONE

RESEARCH ARTICLE

Safety and preliminary efficacy of orally administered lyophilized fecal microbiota product compared with frozen product given by enema for recurrent *Clostridium difficile* infection: A randomized clinical trial

Zhi-Dong Jiang[1], Robert R. Jenq[2], Nadim J. Ajami[3], Joseph F. Petrosino[3], Ashley A. Alexander[4], Shi Ke[1], Tehseen Iqbal[1], Andrew W. DuPont[5], Kenneth Muldrew[6], Yushu Shi[2], Christine Peterson[2], Kim-Anh Do[2], Herbert L. DuPont[1,2,3,4,5,6]*

microorganisms

MDPI

Article

An Oral FMT Capsule as Efficient as an Enema for Microbiota Reconstruction Following Disruption by Antibiotics, as Assessed in an In Vitro Human Gut Model

Cécile Verdier [1,2,†], Sylvain Denis [1,†], Cyrielle Gasc [2], Lilia Boucinha [2], Ophélie Uriot [1], Dominique Delmas [2], Joël Dore [2,3], Corentin Le Camus [2], Carole Schwintner [2,‡] and Stéphanie Blanquet-Diot [1,*,‡]

Introduction

NGS in Gut Microbiota Analysis

- **NGS, Next-generation sequencing**
  - Enables precise **analysis of microbial communities**
- **Diversity Index**
  - Shannon and Simpson index help compare microbial diversity across samples
- **Abundance**
  - Quantifies the relative presence of specific bacterial taxa
- **Functional prediction**
  - Estimates capabilities such as SCFA production or presence of antibiotic resistance genes
- **Disease association**
  - identifies microbiota patterns linked to obesity, inflammation, autism, IBD

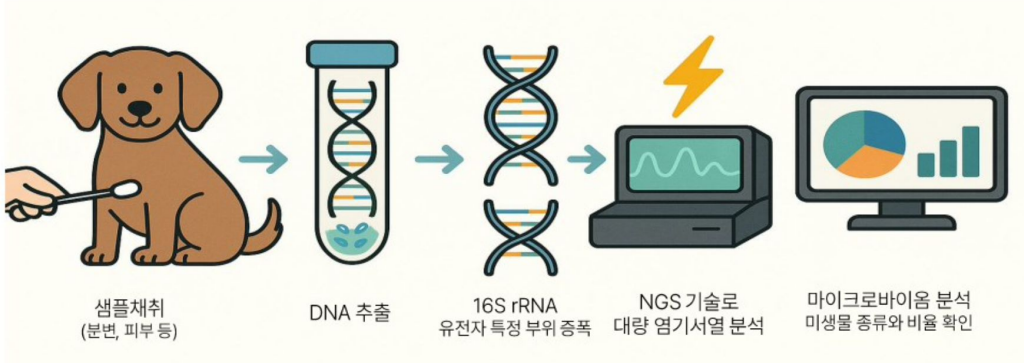


Figure 3. Next-Gen DNA sequencing technology in veterinary medicine

Mechanism of FMT in dogs

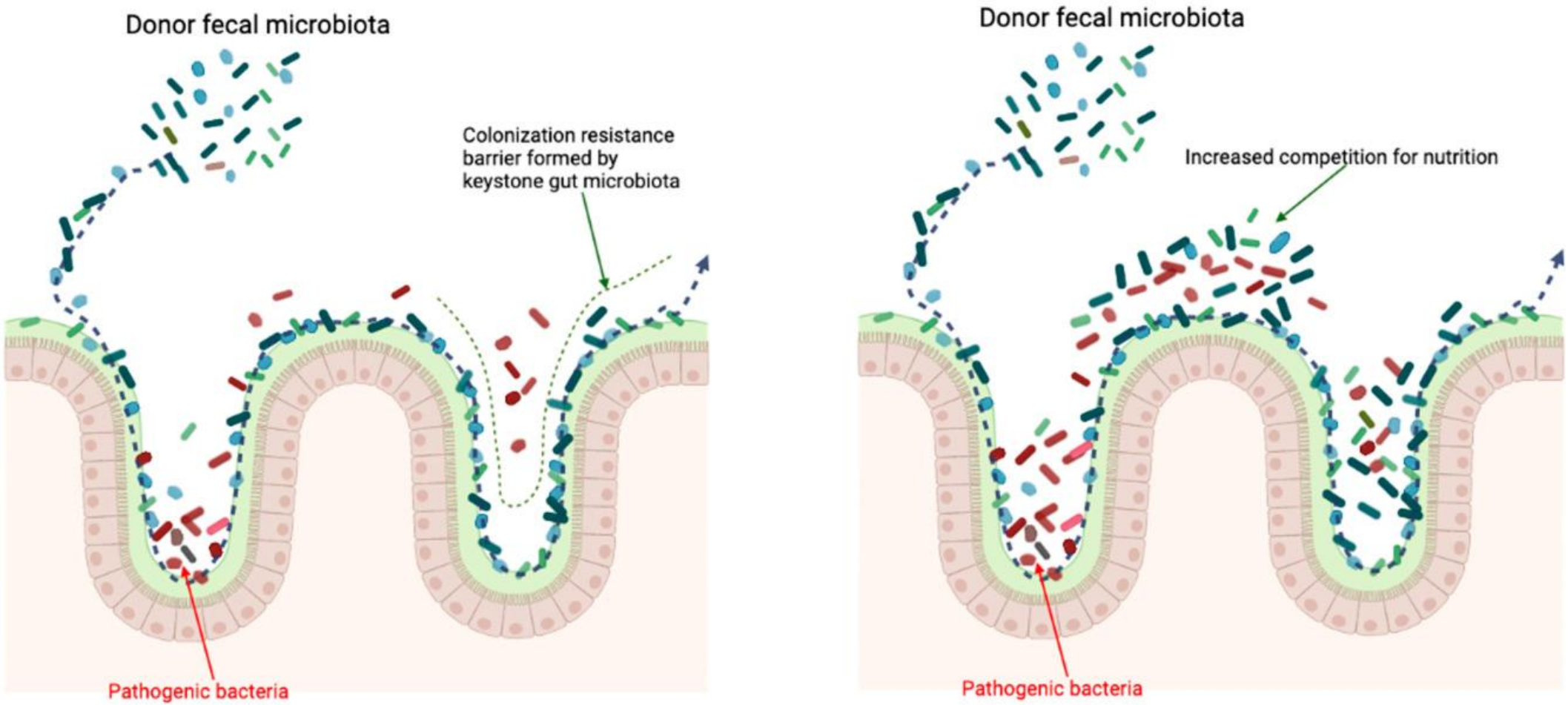
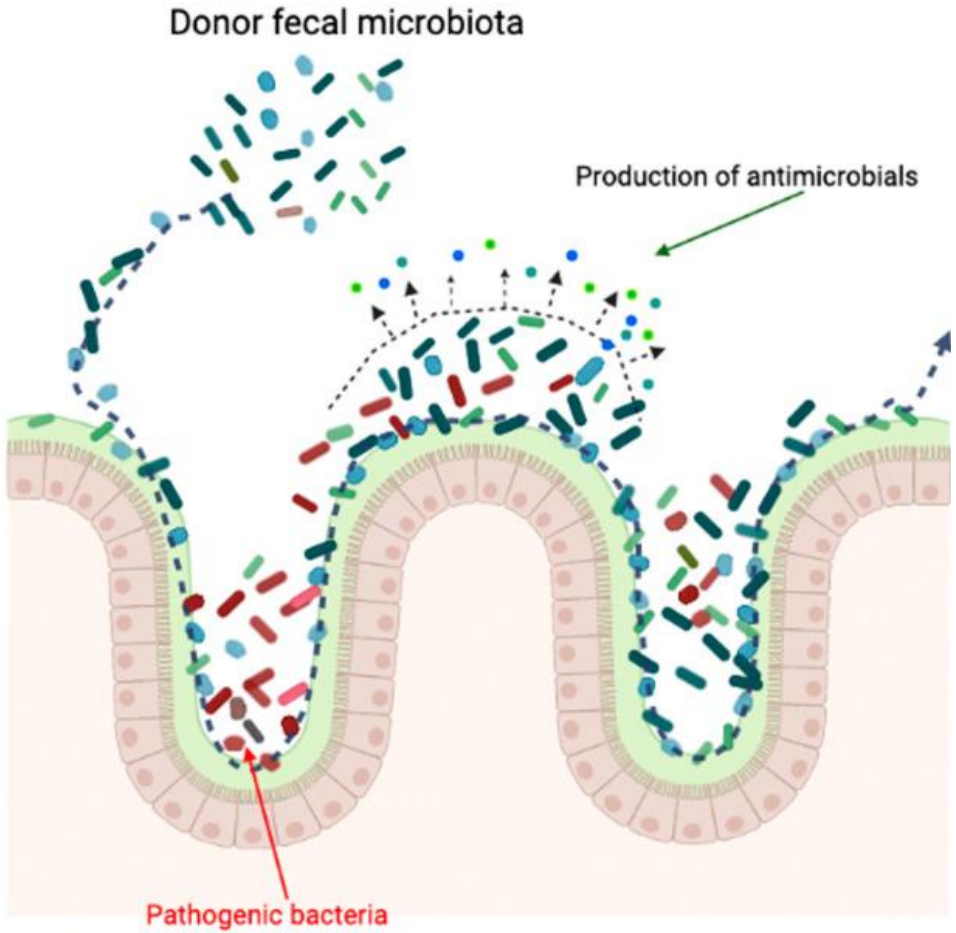


Figure 4. Potential mechanism of FMT

Mechanism of FMT in dogs



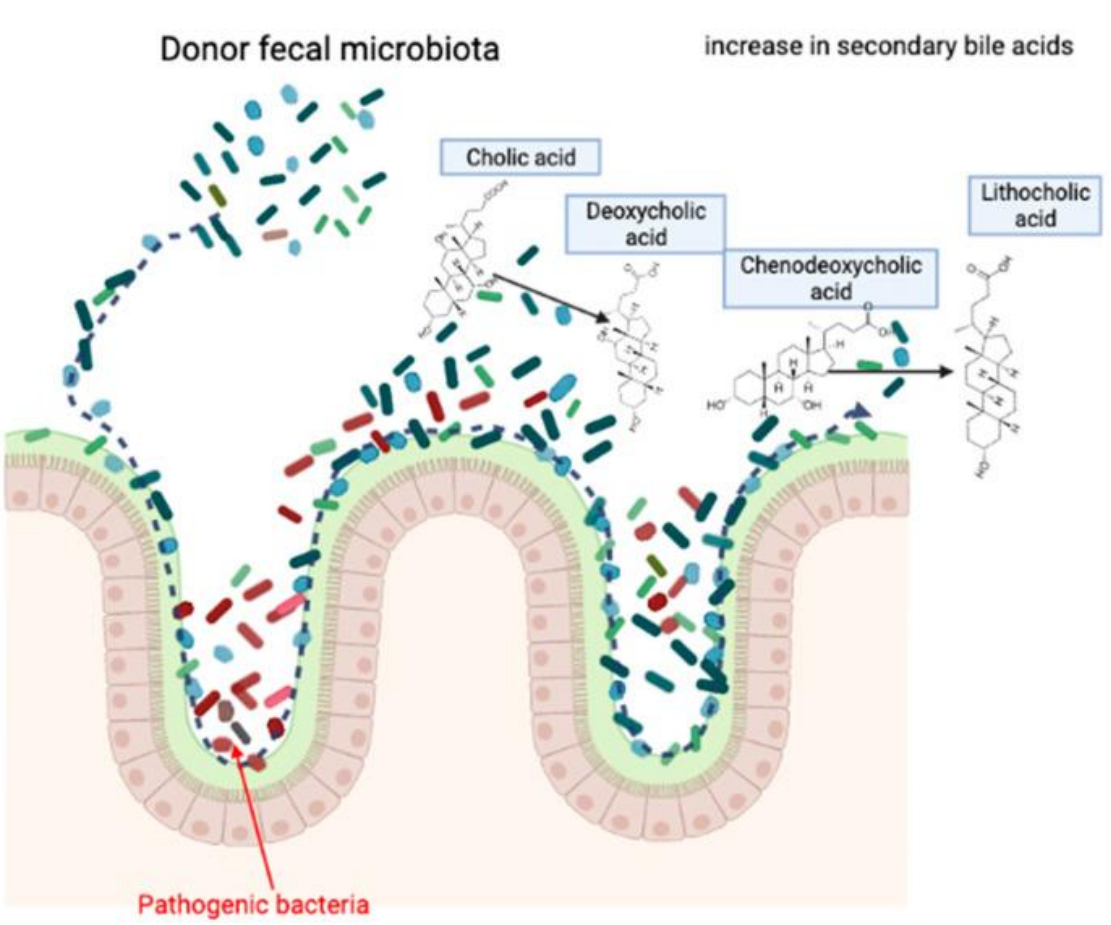
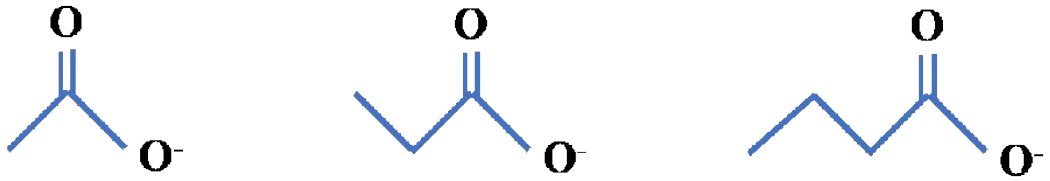


Figure 4. Potential mechanism of FMT

Short-chain fatty acids (SCFAs)

SCFAs

- SCFAs include **acetate**, **propionate**, and **butyrate**.
- They are the **end products of bacterial fermentation** of non-digestible dietary fibers in the colon.



Acetate Propionate Butyrate

Functions of SCFAs

- **Immunomodulation**
  - ↑ Anti-inflammatory cytokines (e.g., IL-10, TGF-β)
  - ↓ Pro-inflammatory cytokines (e.g., IL-6, IL-8, TNF-α)
  - ↑ Activation of Foxp3 (a key transcription factor for immune regulation)
- **Antidiarrheal and Motility Regulation**
  - SCFAs help modulate GI motility and fluid balance.
- **Colonization Resistance**
  - SCFA production lowers colonic pH, **inhibiting growth of pH-sensitive pathogens** like *Enterobacteriaceae* and *Clostridia*.
  - SCFA-rich environments suppress virulence and colonization of enteropathogens.

FMT

Short-chain fatty acids (SCFAs)

- **SCFAs levels in dogs with chronic enteropathy**
  - Clinical studies show that dogs with chronic enteropathy (CE)
  - exhibit significantly **lower fecal concentrations of SCFAs** compared to healthy controls (HC)
- The **reduced SCFA levels** in dogs with CE correlate with significant **dysbiosis**, suggesting a disrupted host–microbiota–metabolite axis. This supports the rationale for therapeutic approaches like **FMT** to restore balance.

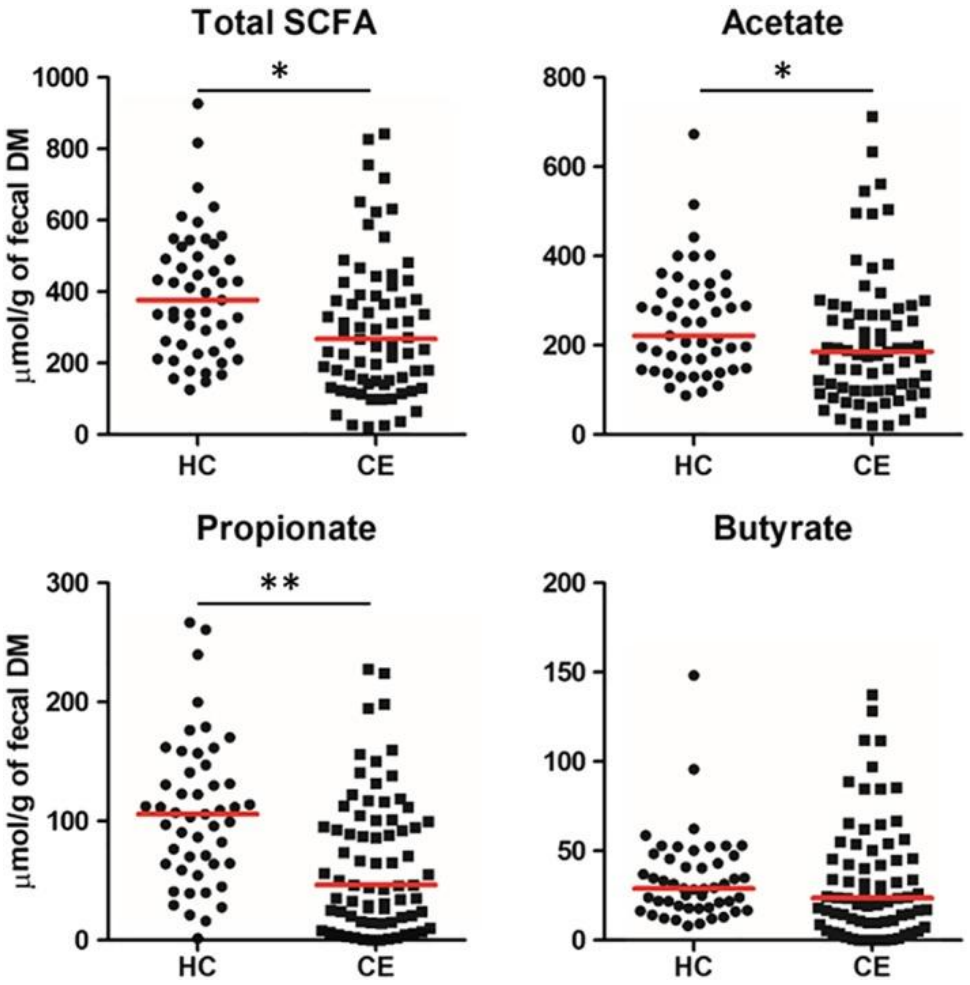


Figure 5. Fecal short-chain fatty acid (SCFA) concentrations in healthy control (HC) dogs and dogs with chronic enteropathy (CE).

Part 3

Clinical Application of FMT

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Chronic Enteropathies

- Some dogs are **non-responsive** to standard treatments (diet, antibiotics, immunosuppressants).
- FMT is being explored as an **adjunctive therapy** for such refractory cases.
- **15–43% of CE dogs** are **non-responsive (NRE)**, with poor long-term prognosis and increased risk of euthanasia

- **Dysbiosis in CE**
  - Meta-analyses show **significant dysbiosis** in dogs with GI disease compared to healthy dogs.
- Dysbiosis features:
  - ↓ **Diversity**
  - ↓ Abundance of *Faecalibacterium*, *Fusobacterium*, *Blautia*, *Turicibacter*, *Clostridium hiranonis*
  - ↑ **E. coli**

veterinary sciences

MDPI

Article

Clinical Effects of Faecal Microbiota Transplantation as Adjunctive Therapy in Dogs with Chronic Enteropathies—A Retrospective Case Series of 41 Dogs

Linda Toresson [1,2,*], Thomas Spillmann [1], Rachel Pilla [3], Ulrika Ludvigsson [2], Josefin Hellgren [2], Gunilla Olmedal [2] and Jan S. Suchodolski [3]

- **Population:** 41 dogs with CE (age: 0.6–13 years, median 5.8)

FMT protocol:

- Route: **Rectal enema**
- Frequency: 1–5 treatments (median: 3), spaced 10–20 days apart
- Dose: 5–7 g/kg body weight
- Administered **alongside ongoing diet and medications**
- **Fasting:** Withhold food for ≥6 h prior; water allowed.
- **Exercise:** Dogs were walked for **30–60 min** to encourage defecation.
- Premedication: Acepromazine 0.1 mg/kg SC, 15 min before FMT

Clinical Application of FMT

Chronic Enteropathies

- **CIBDAI score** (Canine Inflammatory Bowel Disease Activity Index):
  - Baseline: median 6 (range 2–17)
  - After FMT: median 2 (range 1–9) → **significant improvement (p < 0.0001)**

- Disease activity at baseline was further compared between good responders (n = 26) versus short-lasting and poor responders combined (n = 15), but there was no significant difference between the groups.

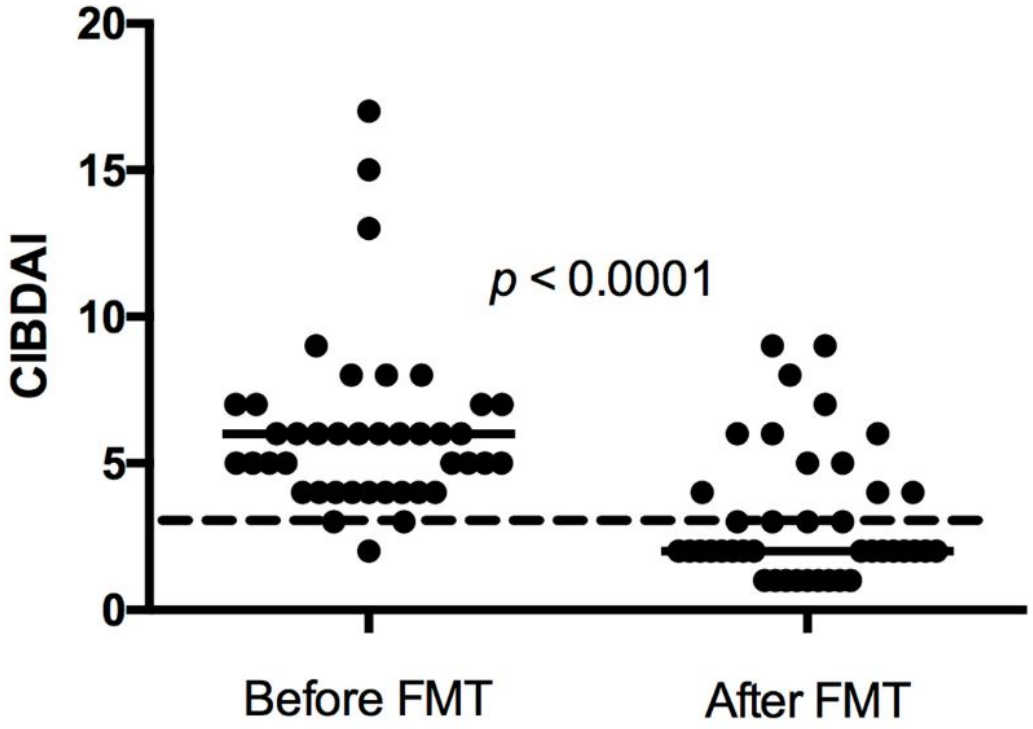

Figure 7. Canine inflammatory bowel disease activity index (CIBDAI) in 41 dogs with chronic enteropathy treated with FMT before FMT and after FMT 3 in dogs receiving 3 or more FMTs. For dogs only receiving 1 or 2 FMTs, the follow-up CIBDAI was calculated after the single FMT or the last of the 2 FMTs. Short horizontal lines represent median. The long striped line represents CIBDAI of 3, which is the upper limit for clinically insignificant disease.

Clinical Application of FMT

Chronic Enteropathies

Response rate

- 31/41 dogs improved
- 24/41 had better stool quality
- 24/41 showed increased activity

Medication Adjustment

- **12 out of 41 dogs**: Reduce corticosteroid dosage, or Discontinue antibiotic use after FMT
- **10 of those 12 dogs**, corticosteroid doses could be tapered to levels that had not been achievable prior to FMT
- The remaining **2 dogs**:
  - Previously experienced **frequent flare-ups**, managed only with **metronidazole or tylosin**
  - After FMT, both dogs could stop regular antibiotics for **3 to 20 months**

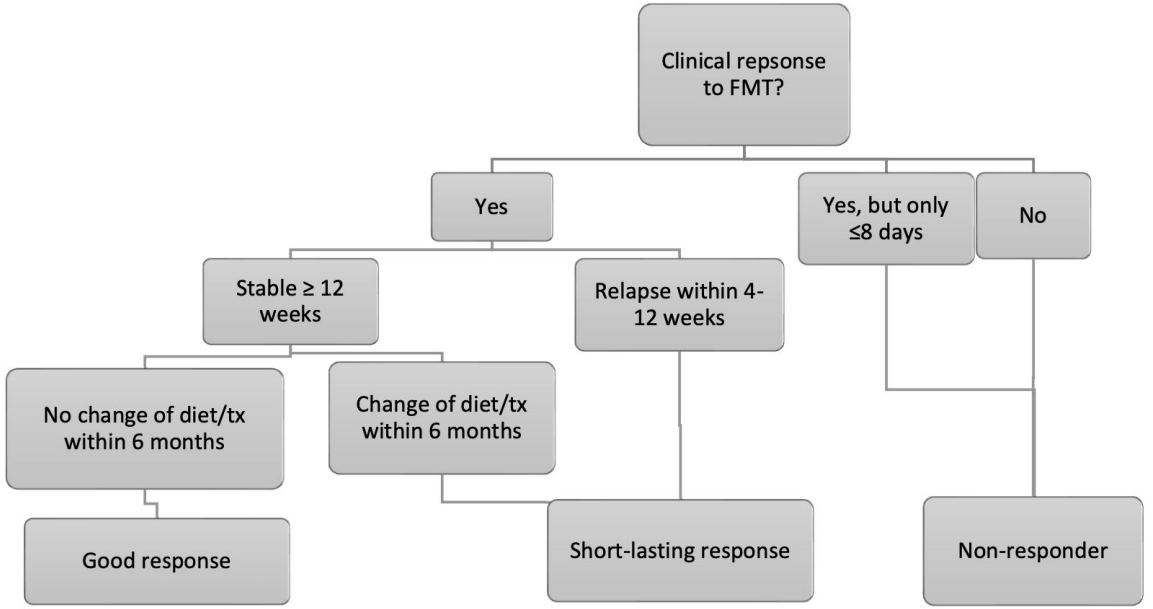

Figure 8. Flow-chart of the classification of response to FMT. Good responders also had to have a minimum **CIBDAI improvement of 2** compared to baseline. If baseline CIBDAI was 4–5, indicating mild clinical disease activity, the response was graded as good if the CIBDAI was consistent, but maintenance therapy could be **tapered to doses that had not been possible before.**

Clinical Application of FMT

Chronic Enteropathies

Adverse Effects

- **10 out of 41 dogs** experienced side effects after FMT: 7 responders, 3 non-responders

- **Gastrointestinal Effects**
  - 7 dogs had **diarrhea or worsening of diarrhea** within 48 hours post-FMT.
  - In all but one non-responder, symptoms **resolved spontaneously within 2–3 days**.
  - 4 of these 7 dogs reacted only to one out of three FMTs

1. One dog (responder):

- **Flare-up of diarrhea + occasional vomiting**
- Occurred **1 week after each of the 3 FMTs**, lasted up to **48 hours**

2. Dog with HUC (histiocytic ulcerative colitis):

- After FMT 1 and 2: **2–3 days of flatulence, foul-smelling feces, and mild vomiting**
- No side effects after FMT 3

3. One dog experienced:

- **Rectal straining and discomfort** for 4 hours, starting 2 hours after FMT 1
- Management for FMT 2 and 3: **No further side effects** after FMT 2 and 3
  - Premedication with **higher dose of acepromazine**
  - Use of **rectal suppository (Xyloproct: hydrocortisone + lidocaine)**
  - **Reduced transplant volume** by mixing with less saline

Clinical Application of FMT

Chronic Enteropathies

Parameter (Number of Dogs)	Good Responders *n* = 26	Short-Lasting Responders *n* = 5	Non-Responders *n* = 10
Euthanasia for refractory GI [a] dx [b]	0	3	4
Additional FMTs performed in	16	1	0
FMT due to recurrence of clinical signs	10	15	N/A
Adding a booster dose	5	3	N/A
Treating new clinical GI signs	1	0	N/A
Clinically stable > 4 w. [c] after additional FMT	15	0	N/A
Tapering of maintenance corticosteroid tx [d]	9	1	0
Clinically long-term stable on decreased doses of corticosteroids	9	0	N/A
Stopping or reducing antibiotics	3/3	0/1	N/A
Treatment with cholestyramine	0	1	5
Response to cholestyramine	N/A	1	2

[a] GI: gastrointestinal, [b] dx: disease, [c] w.: weeks, [d] tx: treatment.

Table 1. Long-term outcome (3–40 months) in 41 CE dogs treated with FMT as an adjunctive therapy.

Clinical Application of FMT

Chronic Enteropathies

Clinical effects of FMT

- Improved fecal quality
- Increased activity

Mechanisms of Increased activity

- Reduced inflammation and pain
- Altered gut-brain axis
- Microbial production of neurotransmitters (e.g., GABA, dopamine)
- SCFAs ↑ → serotonin synthesis (95% of 5-HT resides in gut)

Antibiotic-sparing effect

- FMT reduced or replaced the need for antibiotics in **3 out of 4 dogs** where this was a treatment goal.
- **Tylosin and metronidazole**, as broad-spectrum antibiotics, are known to induce **long-lasting dysbiosis** in dogs.
- In humans, **early-life antibiotic exposure increases the risk of IBD**, especially with broad-spectrum and repeated use (n=194,163; case–control study).
- There's evidence of **antimicrobial resistance gene sharing** between dogs and humans in the same household.
- A good response to FMT in a dog with **relapsing HUC**, which typically requires restricted antibiotics, is particularly promising—**no relapse over 2 years** post-FMT.

Clinical Application of FMT

Chronic Enteropathies

Sequential FMT justification

- Across studies, **dysbiosis recurred after 3–4 weeks** post-FMT.
- In the current study, **23/31 responders improved further after the second FMT**.
- In three dogs, relapse signs just before FMT #2 were reversed after the procedure.
- Similarly, **repeat FMTs were beneficial for relapse** in human patients.

Positive Metabolic Shifts Post-FMT

- In humans, **positive FMT outcomes** have been associated with increased **SCFA biosynthesis** and **secondary bile acids**.

Functions of SCFAs

- Activate **regulatory T cells**, reduce inflammation
- Inhibit **TLR signalling**, serve as energy for colonocytes
- Regulate **gut motility**, maintain **intestinal barrier integrity**

- **Lack of SCFA-producing bacteria** is associated with **inflammation and dysfunction**

Bile Acid Dysmetabolism, Bile Acid Diarrhea

- **Positive response to cholestyramine** in 2 non-responders and 1 short-term responder supports this.
- **Reduced Clostridium hiranonis and secondary bile acids** has been seen in dogs with CE.
- **A lack of secondary bile acids may promote dysbiosis by failing the growth of pathogens like** C. difficile, E. coli, and others

Part 3

Clinical Application of FMT

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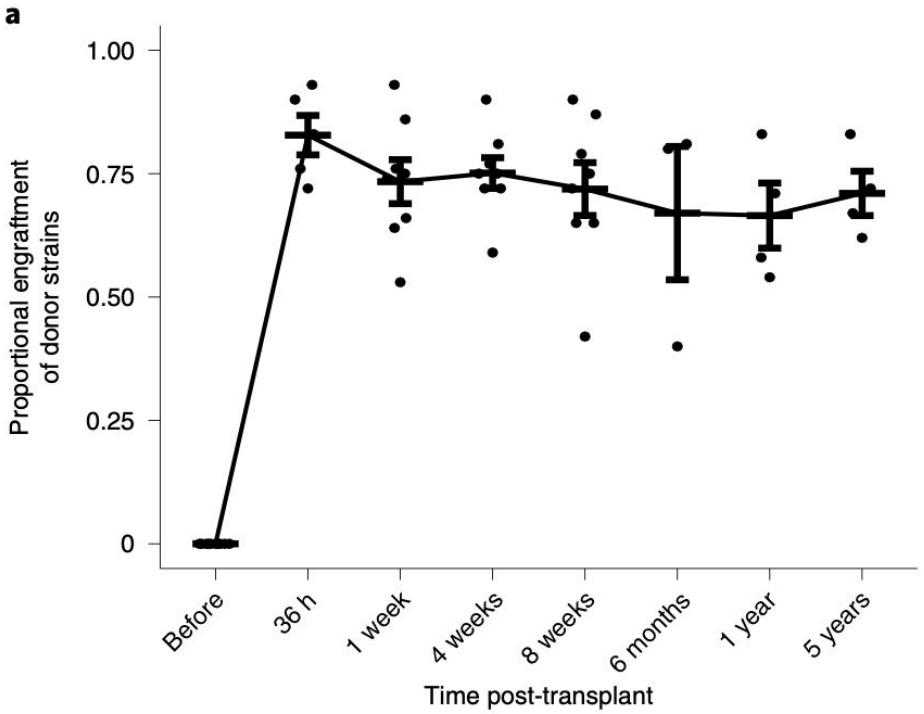
Chronic Enteropathies

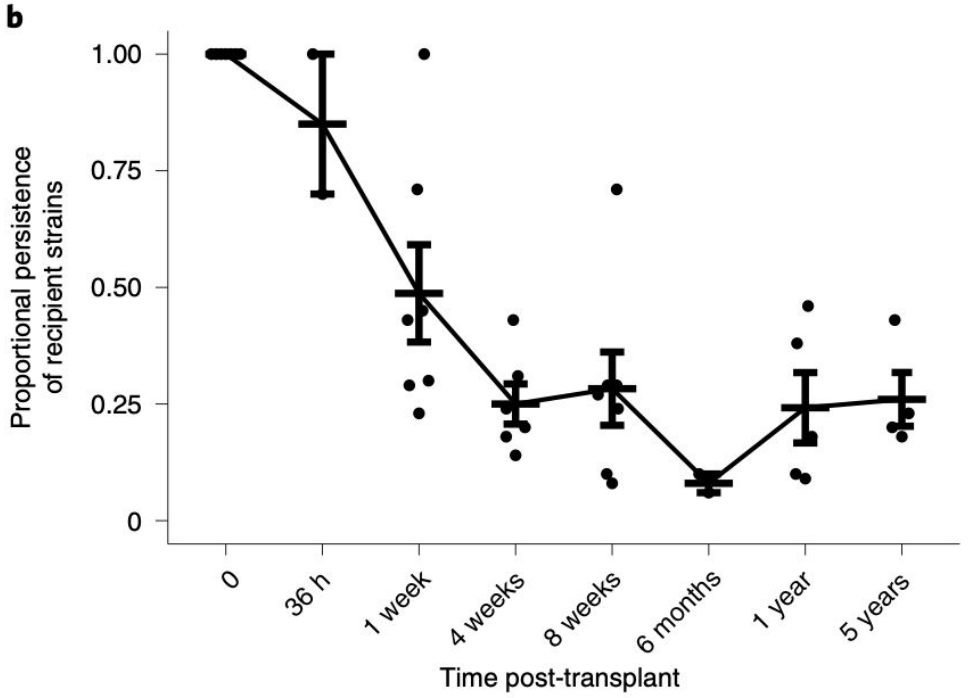
nature microbiology
ANALYSIS
https://doi.org/10.1038/s41564-021-00966-0
Check for updates

OPEN

Precise quantification of bacterial strains after fecal microbiota transplantation delineates long-term engraftment and explains outcomes

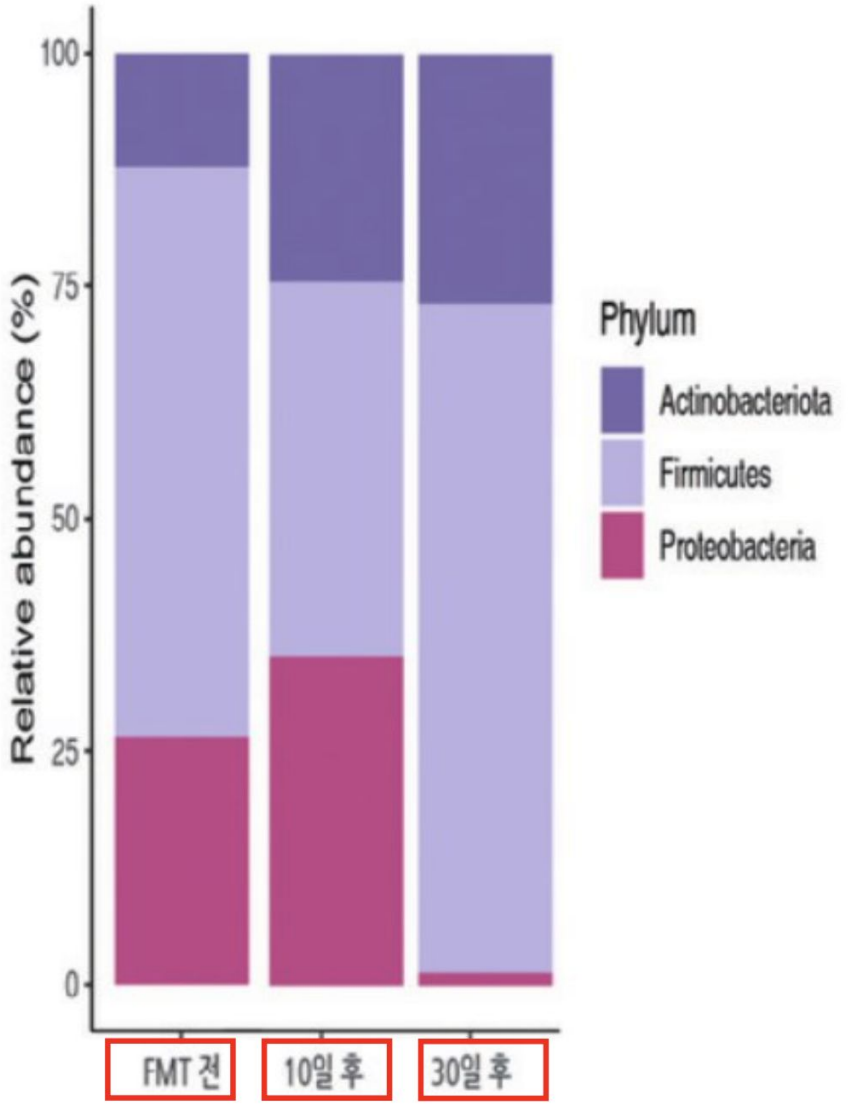
Varun Aggarwala[1,2], Ilaria Mogno[1,2], Zhihua Li[1,2], Chao Yang[1,2], Graham J. Britton[1,2], Alice Chen-Liaw[1,2], Josephine Mitcham[3], Gerold Bongers[1,2], Dirk Gevers[4], Jose C. Clemente[1,2], Jean-Frederic Colombel[3], Ari Grinspan[3] and Jeremiah Faith[1,2]✉

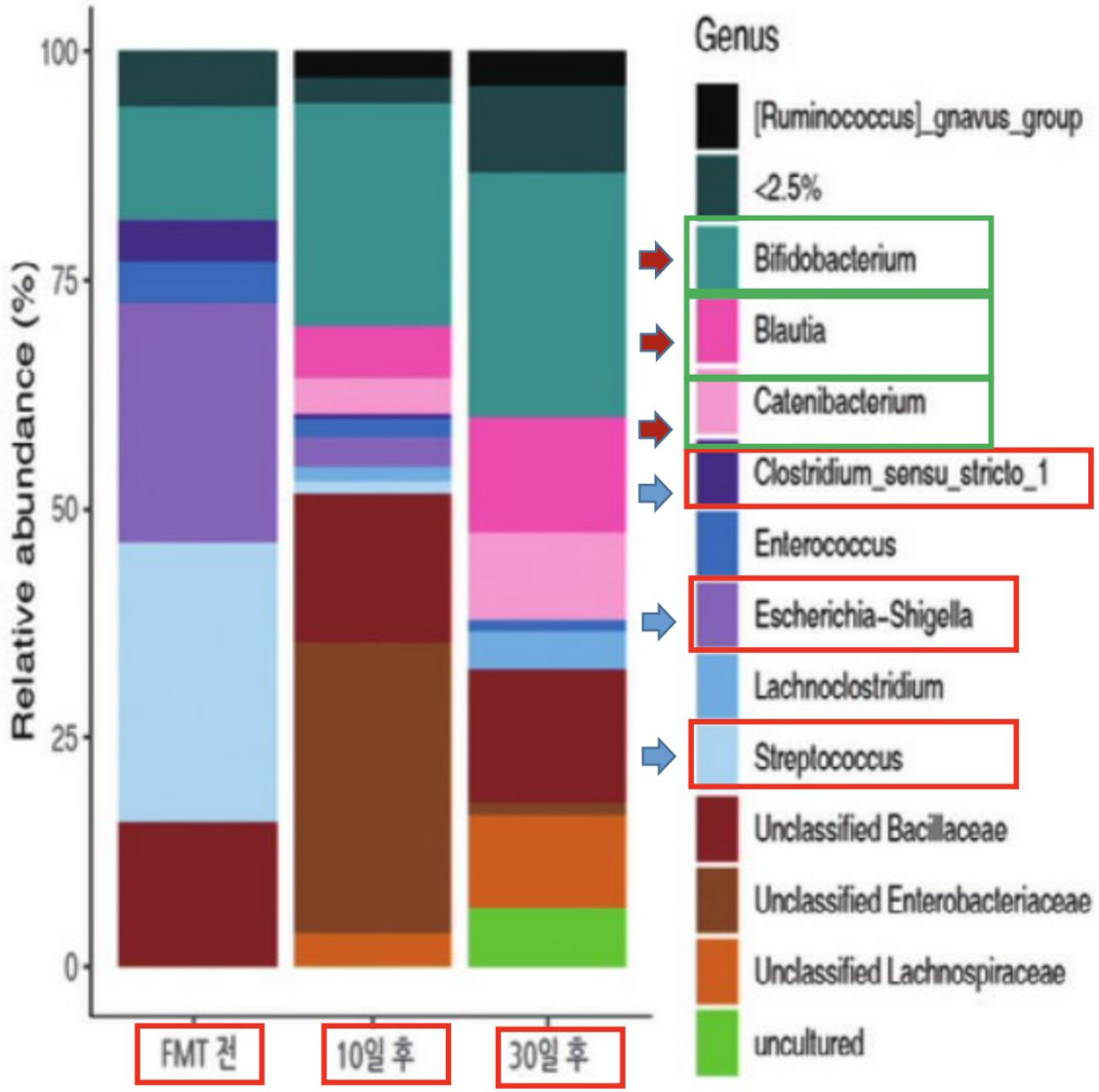




Clinical Application of FMT

Chroni





Clinical Application of FMT

CASE 1 - IBD

- 품종 : 비숑
- 나이 : 2016년생 (9살)
- 성별 : 중성화된 암컷
- 의뢰 병원 : 김천 연합동물병원
- 식이 : Velixer (민감성 알레르기 사료), 사람 먹는 과일 조금 주는 편
- 관절 영양제와 피부 영양제 먹음

  ⇒ FMT 이후로 영양제 중단

Clinical Application of FMT

CASE 1 - IBD

· 2024년 3월부터 설사 및 복수 생성
· 2024년 4월 대구 2차 병원에서 IBD로 진단받음
  - PDS (1mg/kg PO BID), MMF (20mg/kg PO BID) + 기타 약물 등등
· 2024년 5월 4일
  - PDS (0.75mg/kg PO BID), MMF (20mg/kg PO BID) + 기타 약물 등등
· 2024년 5월 18일 – 설사 재발, 복수 재발
  - PDS (1mg/kg), MMF(20mg/kg) + cyclosporine7.5mg/kg SID(추가)
· 2024년 6월 6일
  - PDS (0.75mg/kg), MMF(20mg/kg) + cyclosporine7.5mg/kg SID(추가)
· 2024년 6월 22일
  - PDS (0.75mg/kg), MMF(20mg/kg) +budesonide(3mg/m2 sid)
· 2024년 6월 28일 ⇒ PDS (2mg/kg), MMF(20mg/kg)
· 2024년 7월 10일 ⇒ PDS (1mg/kg), MMF(20mg/kg)

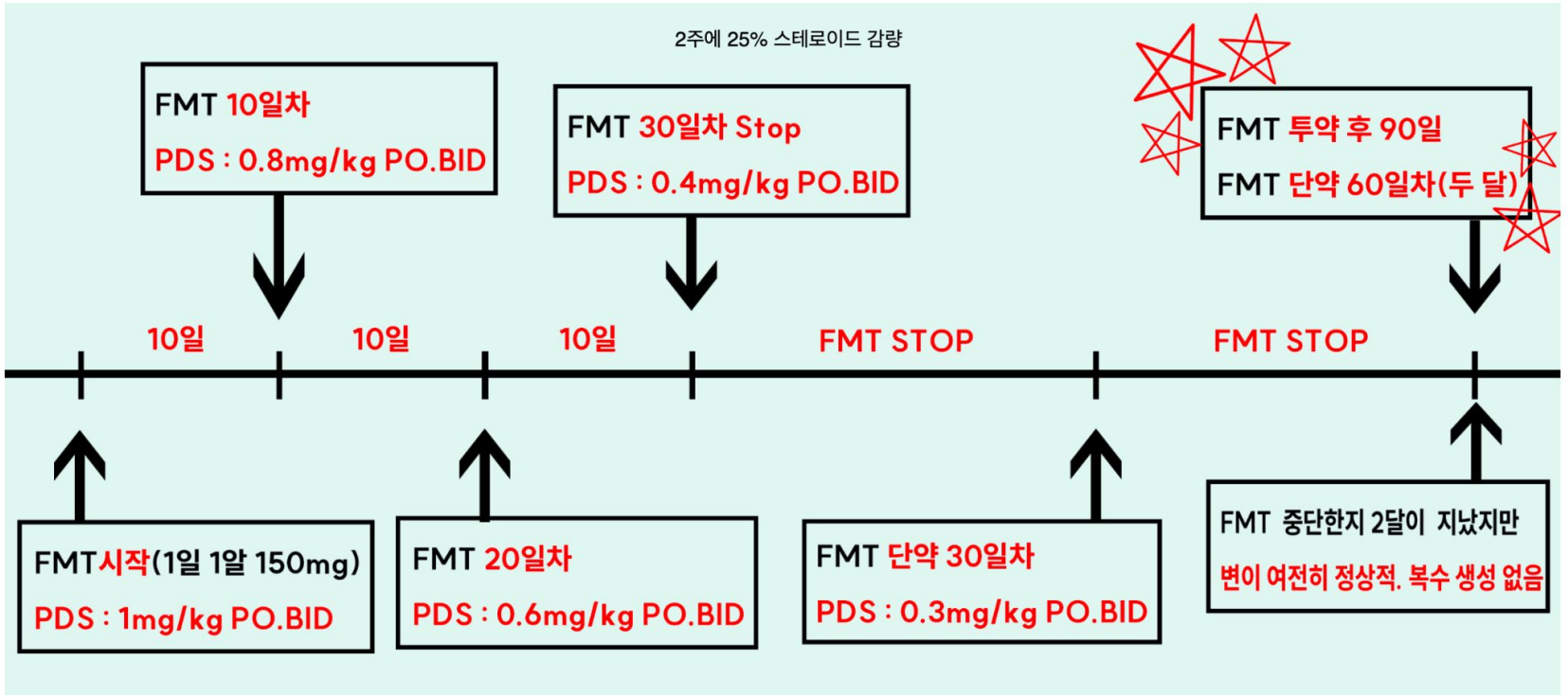
<<<결과적으로>>>

· 2024년 7월 10일부터 2024년 12월 24일까지
  - PDS (1mg/kg), MMF(20mg/kg) 용량으로 그대로 진행
· 2025년 1월 9일 FMT를 하기 위하여 대구동물메디컬로 내원

Clinical Application of FMT

CASE 1 - IBD

* FMT 치료 스케줄 및 고용량 스테로이드 감량 과정



Clinical Application of FMT

CASE 1 - IBD

- FMT 다시 복용 2일에 1개
- PDS (0.3 mg/kg PO SID) + MMF (20mg/kg PO BID)
- 그 이외에 먹는 약은 모두 중단 (영양제도 모두 중단)

- 기타 추가 증상
  - 가려움, 소양감이 줄어듦
  - 다음/다뇨/다식이 줄어듦
  - 활력 상당히 좋음

Clinical Application of FMT

CASE 2 - Pancreatitis

- 품종 : 푸들
- 나이 : 2020년생 (4살)
- 성별 : 중성화된 암컷
- 의뢰 병원 : 구미의 지역병원에서 의뢰
- 식이 : 사이언스(GI BIOME) 2달먹임
  힐메딕스(캔, intestinal),
  사람 음식은 절대 주지 않음
- 환경 : 스트레스 요인 없음

Clinical Application of FMT

CASE 2 - Pancreatitis

· 2024년 11월 18일 ⇒ 구토 3군데, 기력저하 ⇒ 항구토 치료
· 2024년 11월 26일 ⇒ 설사 시작
⇒ metronidazole(7.5mg/kg) 등등
· 2024년 11월 28일 ⇒ 구토 3회, 설사 지속
· 다른 대형 병원에서 2월 말까지 입원 치료 등등하였음
- (3달간, 600만원 병원비 지출했다고 함)
· 2025년 3월 10일
⇒ 다시 흑변/혈변, 구토, 기력저하(GI biome 사료 복용)

· 이전 병원처방약
=>metronidazole+ampicillin+간 영양제+췌장보조제+probiotics 등등

• 2025년 3월 11일 ⇒ 대구동물메디컬센터로 FMT로 레퍼
⇒ FMT 시작 (100mg + 150mg, 1일 1알, 식전·후 4시간 간격으로)
⇒ 이전 병원에서 먹은 약 모두 중단하고 FMT만 복용 진행
·
2025년 3월 21일 (FMT 한 후 10일째)
⇒ 식욕부진, 설사 ⇒ 1일 수액 처치 ⇒ 기존 치료 방식은 그대로 유지

· 2025년 4월 10일 FMT 1달 복용 후 중지
⇒ FMT 중단 후 향후 1개월간 증상을 지켜볼 예정

Clinical Application of FMT

CASE 3 - 항암 부작용

- 품종 : 푸들
- 나이 : 2011년
- 성별 : 중성화 수컷
- 종양 진단 : 2024년 9월 mast cell tumor(MCT)로 진단을 받음
- 현재 항암치료 : palladia, selenase 복용 및 주사
- 증상 : 장염 치료에 반응이 없음
- FMT 시작 : 2025년 3월 30일

- 2024년 9월 6일 ⇒ 종양 제거 수술 진행
- 2024년 10월 2일 ⇒ 팔라디아 복용 시작(25mg 시작)
- 2024년 11월 23일 ⇒ 변이 묽어짐, 구토 없음
- 2024년 12월 7일 ⇒ 설사 증상이 더 심해짐, 셀레늄 주사 및 복용 시작
- 2025년 1월 5일
  ⇒ 수양성 설사, 간헐적인 구토 시작. 팔라디아 15mg, 25mg, 번갈아 복용, 지사제 처방
- 2025년 3월 8일 ⇒ 설사 증상으로 팔라디아 15mg으로만 복용
- 2025년 3월 22일 ⇒ 대구메디컬센터로 설사 변을 보냄
- 2025년 3월 30일 ⇒ FMT 시작
- 2025년 4월 6일 ⇒ FMT 복용 3일째부터 변 상태가 좋아짐

Clinical Application of FMT

CASE 4 - Chronic diarrhea (unknown cause)

· 환자 명 : 무탈이
· 배경 : 전현무 아나운서가 유기견으로 입양한 강아지
· 나이 : 2023년 생(2살)
· 증상 : 계속 적인 혈변, 점액변로 인한 체중 감소, 피부병, 탈모
  - 10개월간 서울/경기도에 병원에서 진단을 받았지만, 원인을 모르겠다고 언급 받음. 치료 효과도 미비함
· 사료 : 알레르기, 식이 과민 사료 등등 알레르기 준한 사료 먹음
· 환자의 검사 자료 및 치료 등등 자료 없이 그냥 FMT(150mg) 1통을 주면서 1일 3알 먹일 것을 권유

· 2024년 11월 초 ⇒ FMT 1통(150 mg)을 줌

· 3알씩 10일 먹으라고 언급함(하지만, 7일만 먹임)
  ⇒ 변이 많이 잡혔다고 연락받음

· 2024년 11월 ~ 2025년 2월 말까지
  ⇒ FMT 중단한지 3달이 지나도 변이 좋다고 함
· 2025년 2월 20일 ⇒ FMT 1통 더 줌
· 2025년 4월 7일 ⇒ 변 상태가 더욱더 완벽해진 것 같다고 함
  ⇒ ***지금은 일반 하림 사료 먹어도 변이 너무 완벽하다고 함

Clinical Application of FMT

CASE 5 - Refractory IBD

- 품종 : 몰티즈
- 나이 : 2013년생(11살)
- 성별 : 중성화된 수컷
- 의뢰 병원 : 지역 병원에서 의뢰
- 식이 : 엔케이 1일 1팩
  ⇒ 이전에는 알레르기 사료를 계속 먹임

- 2024년 10월 11일 ⇒ 1주 전 구토, 식욕부진, 체중 감소
  ⇒ 보호자가 2차 병원 가기 싫다고 함
- 2024년 10월 14일 ⇒ 점액 변 2회
- 2024년 10월 18일 ⇒ PDS 0.5 mg/kg PO BID 시작
- 2024년 10월 25일
  ⇒ PDS 0.2 mg/kg PO BID 소화기 증상 개선으로 감량함
- 2024년 10월 30일 ⇒ 점액성 설사 시작, 식욕절폐
  ⇒ 다시 PDS 0.5 mg/kg PO BID로 증량
- 2024년 11월 1일 ⇒ 2차 병원으로 의뢰

Clinical Application of FMT

CASE 5 - Refractory IBD

- 2025년 1월 2일 ⇒ 2차에서도 치료 효과 없다고 다시 처음 병원으로 돌아옴 ⇒ PDS(0.4 mg)
- 2025년 1월 8일 ⇒ 설사는 조금 개선 PDS(0.4mg)
- 2025년 1월 15일 ⇒ 설사가 더 심해짐 PDS(0.3mg)으로 변경
- 2025년 1월 21일 ⇒ 대구동물메디컬센터로 레퍼
  ⇒ PDS(1 mg/kg PO BID), MMF(20 mg/kg PO BID)
  ⇒ 약 7~10일간 임상증상 경과를 본 후 약물 용량 조절 예정

- 2025년 1월 23일 처치
  - 엑소좀 1차,
  - FMT 1알,
  - PDS (1mg/kg PO BID),
  - MMF(20mg/kg PO BID)

- 2025년 1월 27일
  ⇒ 엑소좀 2차 투여

- 2025년 1월 30일
  ⇒ 사망

Clinical Application of FMT

CASE 5 - Refractory IBD

- Patient selection, the **timing of FMT**, **administration route**, **how much of FMT** and **routine treatment** (Top-Down approach) likely impact the outcomes of FMT.

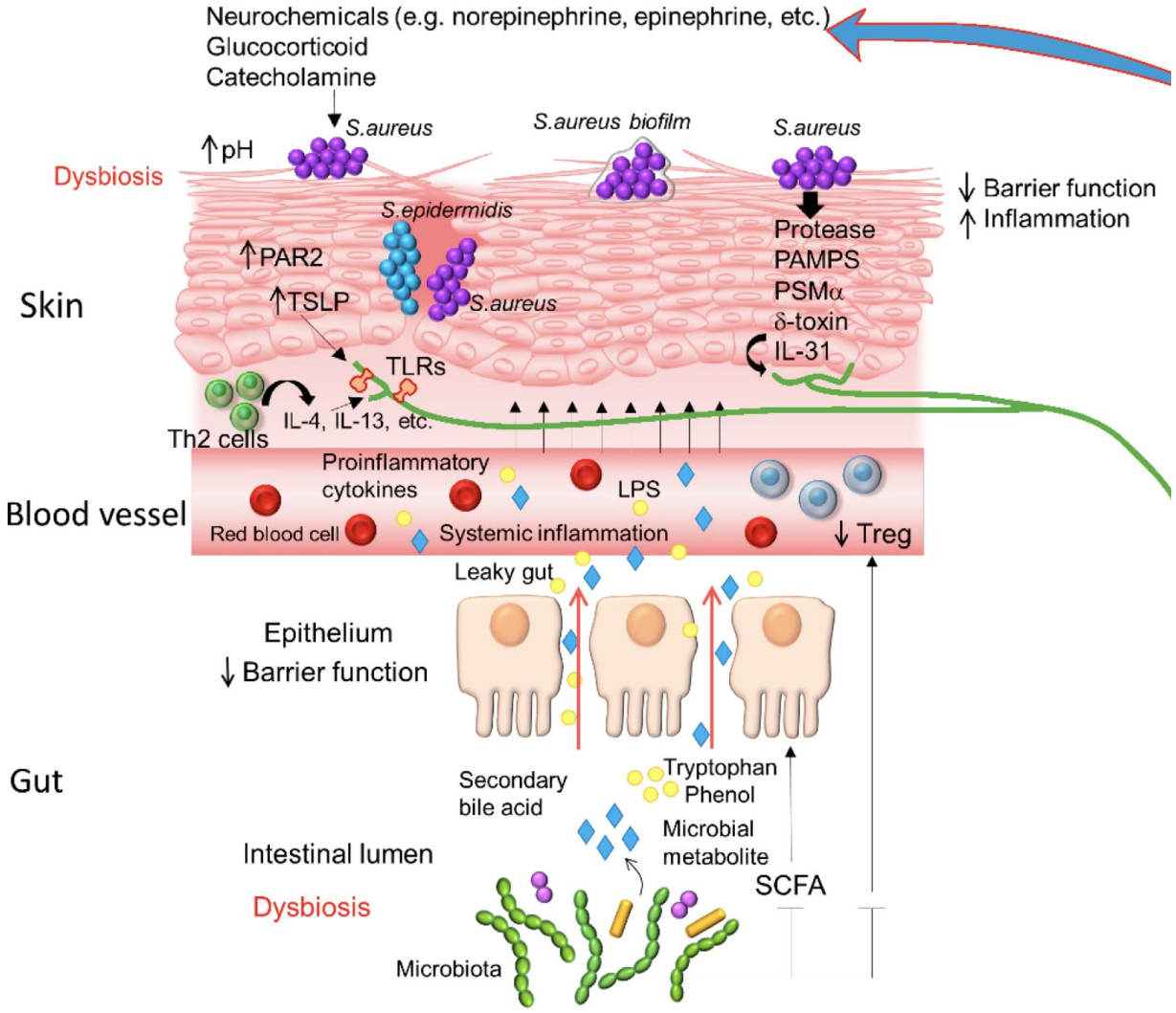
- FMT => 경구로 5알씩 4일간 투여
- FMT => 직장내로 50ml 당일 투여
- PDS => 2mg/kg PO BID로 고용량으로 투여
- MMF => 20mg/kg PO BID로 투여(결장 출혈이 생길 수 있으니, MMF는 배제)
- Cyclosporine => 5mg/kg PO SID로 동시 투여(한미?, 샌디문? 캡슐? 액상?)
- 엑소좀 => 3일에 1번씩

Clinical Application of FMT

Atopic dermatitis

Gut-Skin Axis

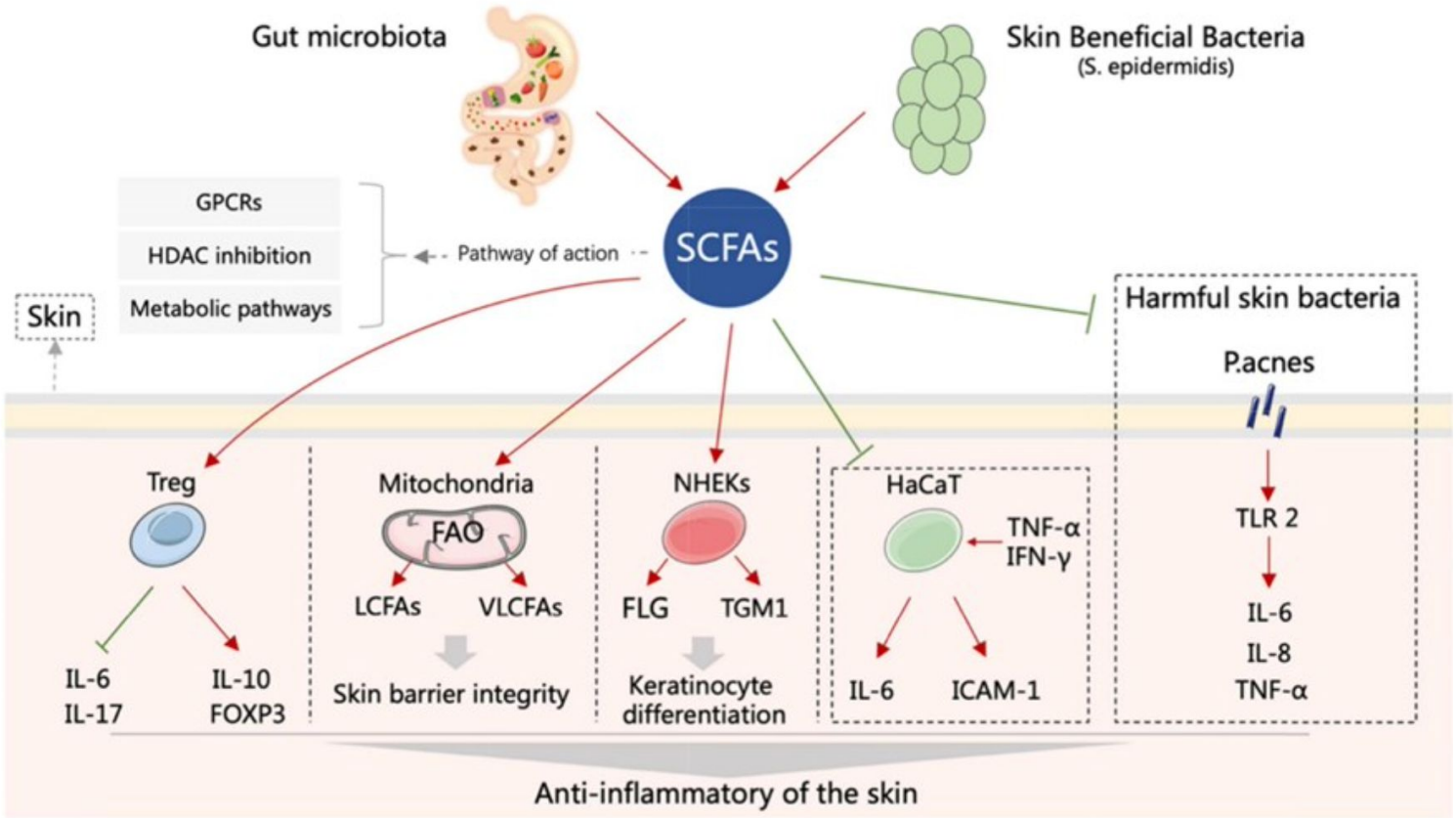
- Dysbiosis (Microbial diversity ↓)
- **Inflammatory cytokine modulation**: Gut inflammation → systemic inflammation → impair skin barrier function
- **Reduced SCFAs production**: Low SCFAs → increased skin inflammation, impaired skin immune balance
- Increased gut permeability (**leaky gut**): translocation of microbial toxins into the bloodstream may trigger skin reactions
- Loss of immune tolerance: Dysbiosis → **reduction in Treg cells → excessive immune responses**



Clinical Application of FMT

Atopic dermatitis

FMT

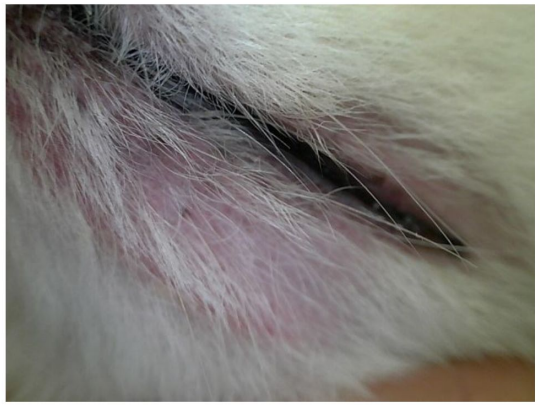


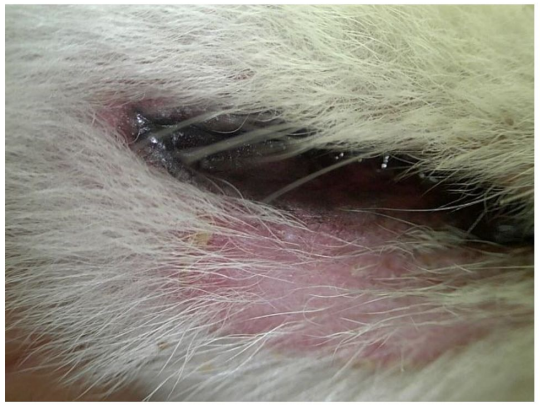
- Activation of regulatory T cells (Tregs) → immune tolerance and anti-inflammatory regulation in skin
- Mitochondrial regulation → promote fatty acid oxidation (FAO) → maintain epidermal barrier integrity
- Regulation of NHEKs (normal human epidermal keratinocytes) → promote keratinocyte differentiation → strengthen skin barrier
- Regulation of HaCaT cells → reduce pro-inflammatory cytokine secretion
- Modulation of the skin microbiome

Clinical Application of FMT

CASE 6 - Atopic dermatitis

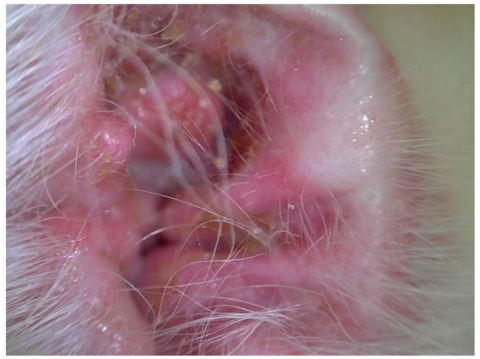
- 품종 : Pomeranian, 나이 : 8y 성별 : 중성화 수컷. 체중 : 3.8kg
- 증상 : 심한 소양감, 탈모, 발진, 가피형성, 10개월간 치료효과 미비
- 24년초 입술, 귀 피부 병변 치료
  - 항생제, 스테로이드 사용시 초기 반응 있었으나,
    이후 증상 개선 없음
  - 사이클로스포린 복용 후 증상 호전되었으나, 추가 호전 없음

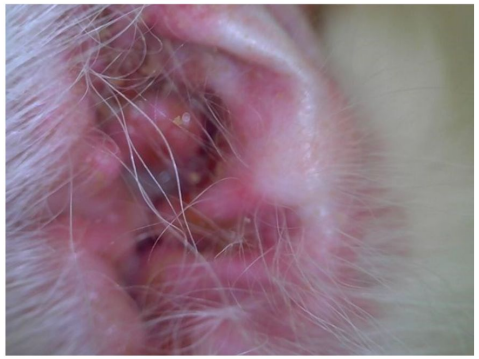




눈 주위에 염증과 탈모가 심한 상태

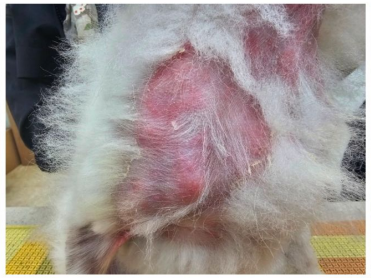
- 항생제, 스테로이드 사용에도 피부 증상 호전되지 않음

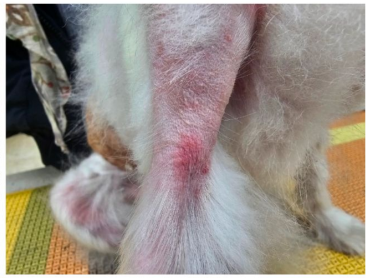




외이도의 염증이 심한 상태

- 사이클로스포린 중단시 피부 증상 악화



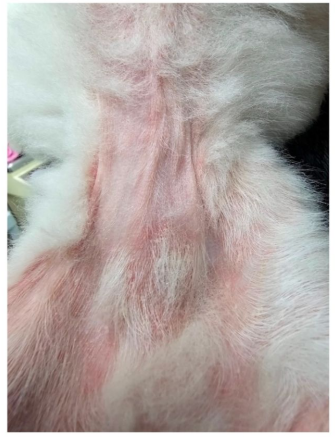
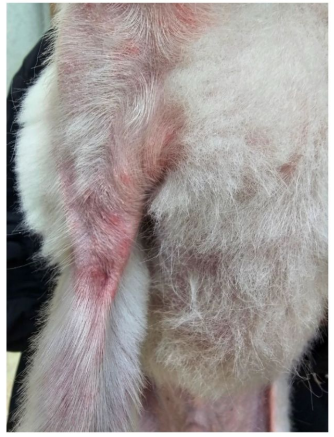


목밑에 탈모와 각질/비듬이 심하고, 염증으로 발적이 심한 상태

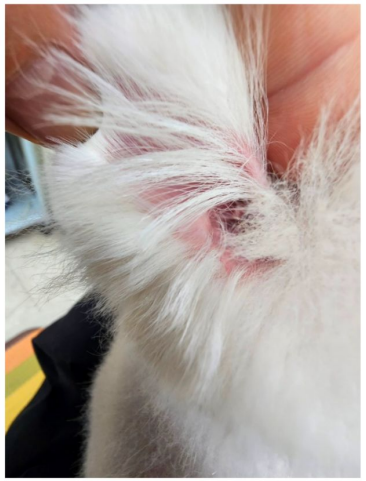
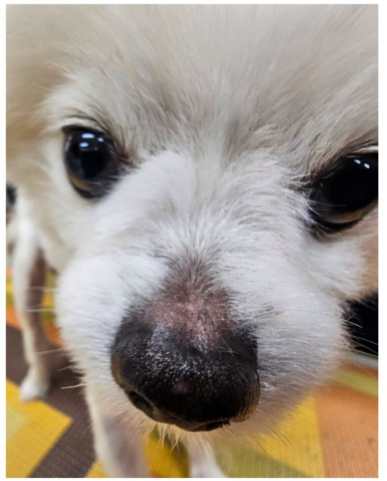
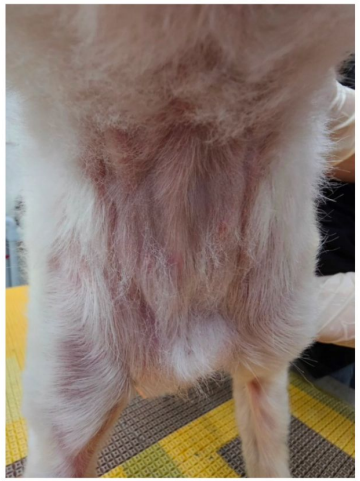
다리에도 피부염이 심함

Clinical Application of FMT

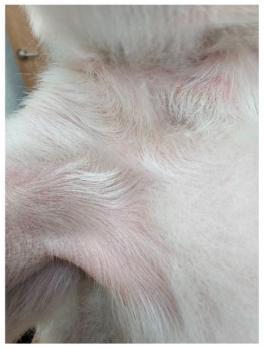
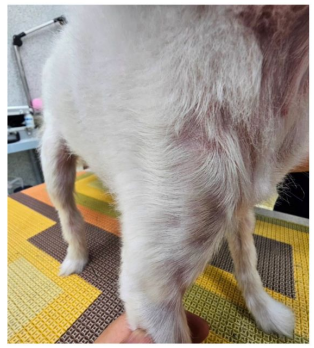
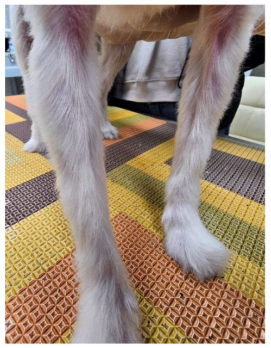
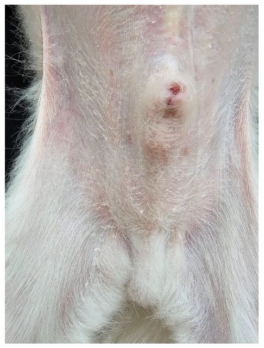
CASE 6 - Atopic dermatitis


FMT 1주일 복용 후 목덜미와 다리에 비듬과 탈모, 발적이 많이 줄어듬

FMT 2주일 복용 후 외이도염이 많이 좋아지고, 입술과 눈주위에 염증감소, 털이 남

FMT 2주일 복용 후 사지와 배쪽 피부가 많이 좋아짐

Clinical Application of FMT

Atopic dermatitis

Indication

- **Limited or partial response to standard treatment** (corticosteroids, antihistamines, cyclosporine, oclacitinib)
- **Comorbid allergic dermatitis and IBD:** strongly indicates gut dysbiosis
- **History of frequent antibiotic or steroid use**: loss of microbial diversity

scientific reports

OPEN

Pilot evaluation of a single oral fecal microbiota transplantation for canine atopic dermatitis

Koji Sugita[1,2], Ayaka Shima[3], Kaho Takahashi[1], Genki Ishihara[3], Koji Kawano[4,5] & Keitaro Ohmori[1,6]✉

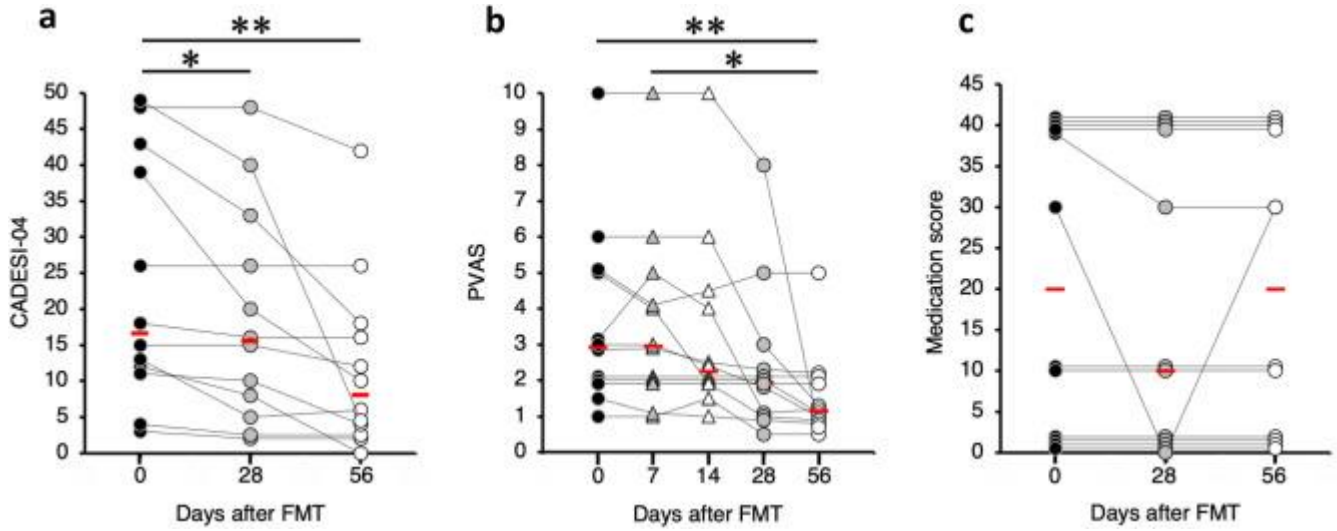


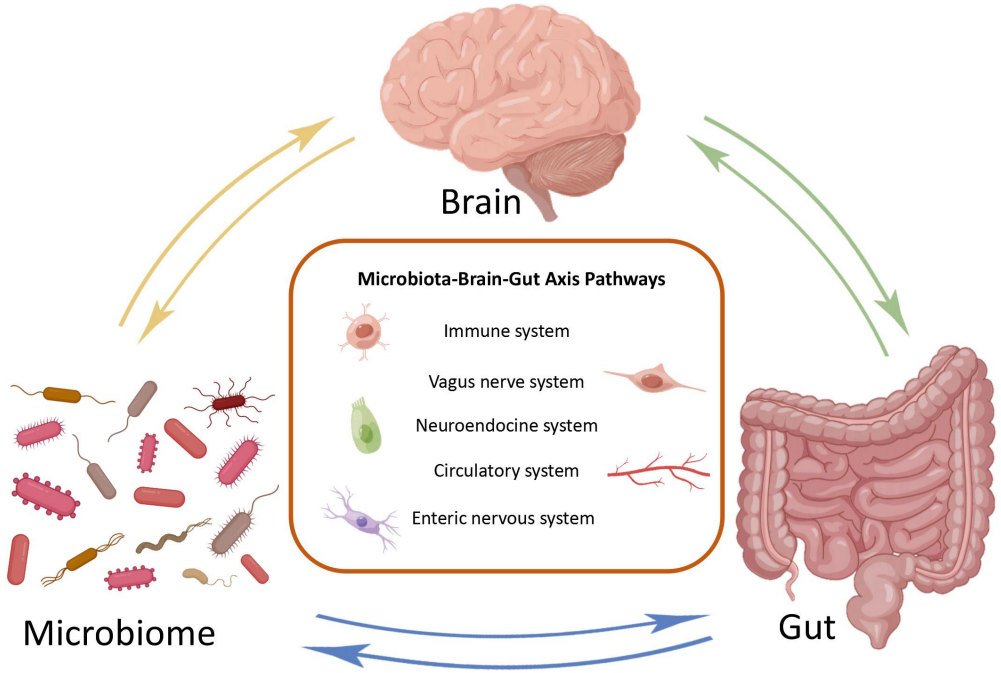
Figure 7. Changes in clinical scores of 12 dogs with atopic dermatitis after a single oral fecal microbiota transplantation. (a) Canine Atopic Dermatitis Extent and Severity Index (CADESI)-04. (b) Pruritus Visual Analog Scale (PVAS). (c) Medication score.

Clinical Application of FMT

Brain Diseases

Gut-Brain Axis

- Gut-Brain are closely connected, interacting through the **immune system, vagus nerve, and endocrine system**
- Regulation of Neurotransmitters
  - Gut microbiota influence the production of neurotransmitters like **GABA** and **serotonin**
  - More than 90% of serotonin is produced in the gut
- Modulation of Inflammation and Immune Response
- Direct Signaling via the **Vagus Nerve**



FMT

- Restoration of microbial diversity → **reduced intestinal inflammation**, **immune homeostasis** → restore brain function
- Increased SCFAs production → **reduce neuroinflammation, protect neurons**
- Normalization of neurotransmitter metabolism (GABA, serotonin) → **reduce anxiety, stabilize mood, lower seizure sensitivity**
- Improved gut barrier function → repair leaky gut → **reduce neurotoxicity, inflammation**

Clinical Application of FMT

Brain Diseases

Indication

- **Epilepsy**: reduce the frequency and severity of seizures
- **CCD** (Canine Cognitive Dysfunction): help slow cognitive decline and improve behavioral disturbances in CCD
- **Anxiety, Separation anxiety, aggression**: promote emotional regulation and anxiety relief
- **Obsessive-Compulsive and abnormal behaviors**: restore balance in neurotransmitter metabolism (GABA, Serotonin)

animals

MDPI

Review

The Relationship between Canine Behavioral Disorders and Gut Microbiome and Future Therapeutic Perspectives

Paula Kiełbik * and Olga Witkowska-Piłaszewicz

Review > Open Vet J. 2025 Feb;15(2):556-564. doi: 10.5455/OVJ.2025.v15.i2.6.
Epub 2025 Feb 28.

Poop for thought: Can fecal microbiome transplantation improve cognitive function in aging dogs?

Curtis Wells Dewey [1]

Affiliations + expand

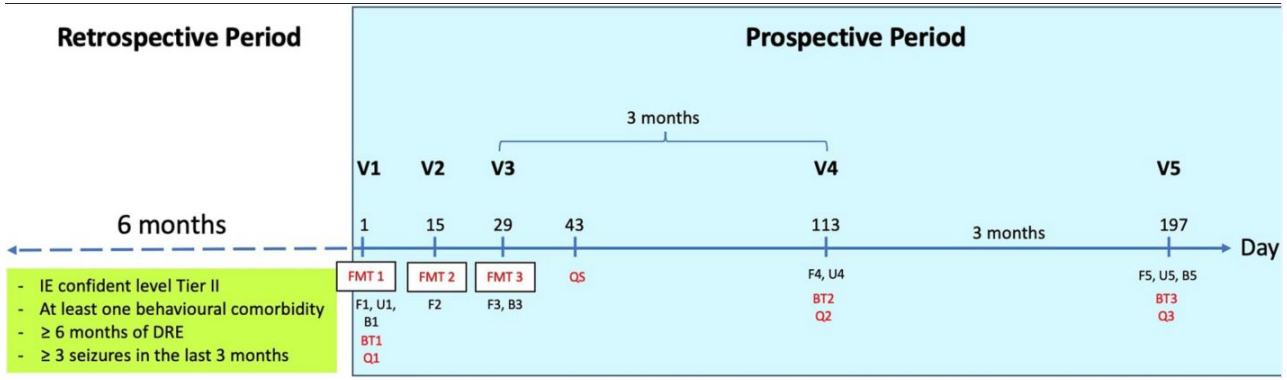
PMID: 40201831 PMCID: PMC11974304 DOI: 10.5455/OVJ.2025.v15.i2.6

Clinical Application of FMT

CASE 7 - Canine Epilepsy

Dogs, Study design

- 9 dogs with drug-resistant epilepsy and behavioral comorbidities



FMT protocol

- 2.5 - 5 g/kg, three FMTs were administered, 2 weeks apart
- At least **two-thirds of the catheter** was inserted rectally into the colon, depending on body size and tolerance
- **No sedation or anesthesia** was needed
- Dogs were **discharged home immediately** after FMT
- Feeding and physical activity were **restricted for 4–6 hours** post-procedure to reduce risk of defecation

Behavioral comorbidities treatment by fecal microbiota transplantation in canine epilepsy: a pilot study of a novel therapeutic approach

Antja Watanangura[1,2,3], Sebastian Meller[1], Nareed Farhat[4], Jan S. Suchodolski[5], Rachel Pilla[5], Mohammad R. Khattab[6], Bruna C. Lopes[5], Andrea Bathen-Nöthen[7], Andrea Fischer[8], Kathrin Busch-Hahn[8], Cornelia Flieshardt[9], Martina Gramer[10], Franziska Richter[2,10], Anna Zamansky[4] and Holger A. Volk[1,2*]

Clinical Application of FMT

CASE 7 - Canine Epilepsy

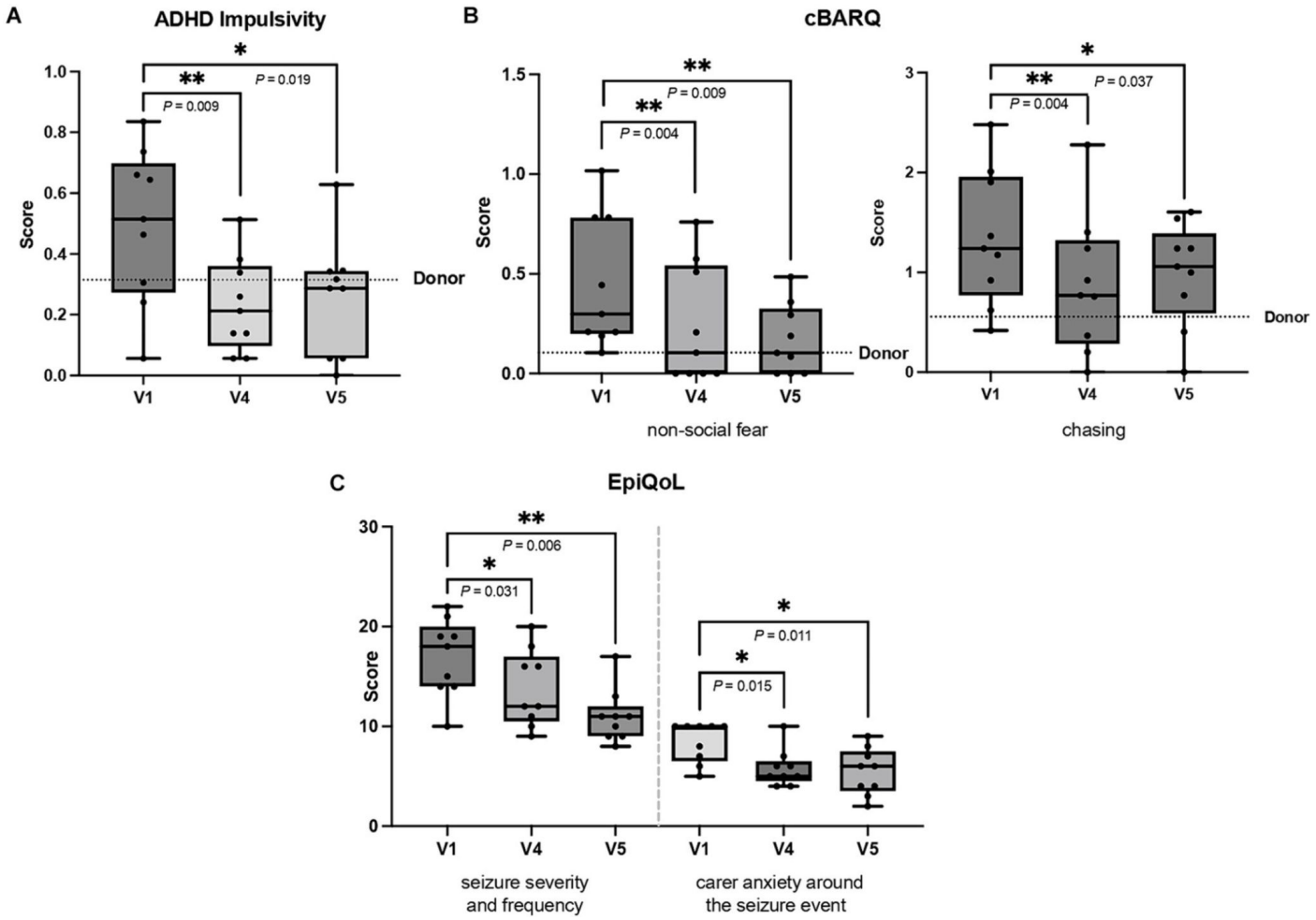


Figure 4. (A–C) The figures show significant improvement in (A) attention deficit hyperactivity disorder (ADHD) impulsivity and (B) non-social fear and chasing behavior from canine behavioral assessment and research questionnaire (C-BARQ) and (C) seizure severity and frequency, and carer anxiety around the seizure event from quality of life questionnaire (EpiQoL).

(A) Reduction in ADHD-like Impulsivity

- Significant **decrease** in impulsivity and inattention after FMT (*p < 0.05)

(B) Decrease in Non-Social Fear and Chasing Behavior

- Notably **reduced** post-FMT (*p < 0.05)

(C) Decreased Seizure Severity & Caregiver Anxiety

- Both seizure events and owner stress levels **significantly improved** (**p < 0.01)

Part 3

Clinical Application of FMT

비엔동물전문의료센터
BIEN ANIMAL MEDICAL CENTER

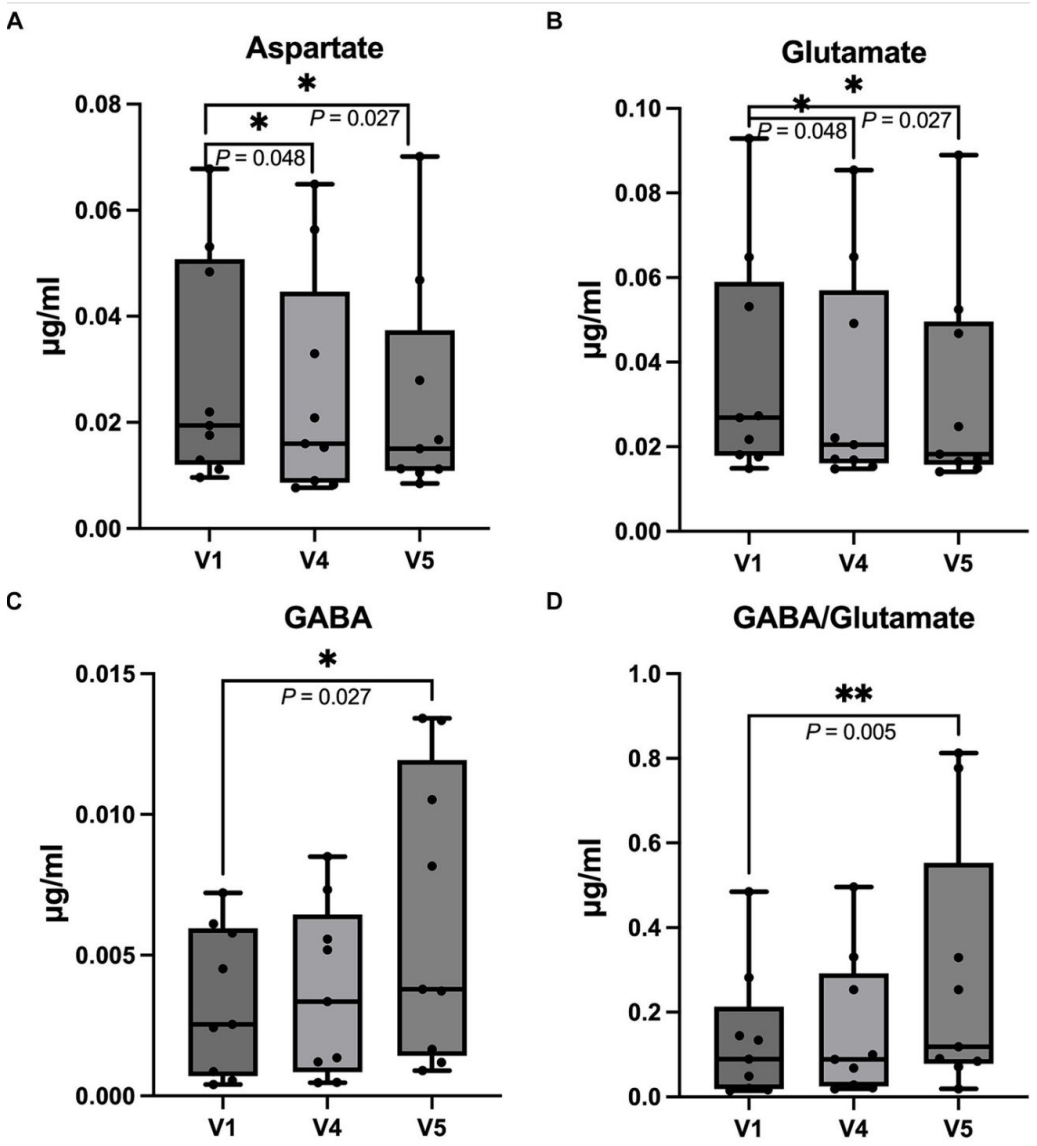
CASE 7 - Canine Epilepsy

Figure 4. Box and whisker plots demonstrate a comparison of the urinal neurotransmitter concentration at the first appointment before FMT (V1) with the fourth (V4, three months after FMT) and fifth follow-up time point (V5, six months after FMT).

- The **excitatory neurotransmitters aspartate and glutamate** were decreased, while the **inhibitory neurotransmitter gamma-aminobutyric acid (GABA**) and **GABA/glutamate ratio** were increased compared to baseline.

Conclusion

- Behavioral comorbidities in canine IE could be alleviated by FMT.
- This study highlights FMT's potential as a novel approach to improving behavioral comorbidities and enhancing the quality of life in canine patients with epilepsy.



Clinical Application of FMT

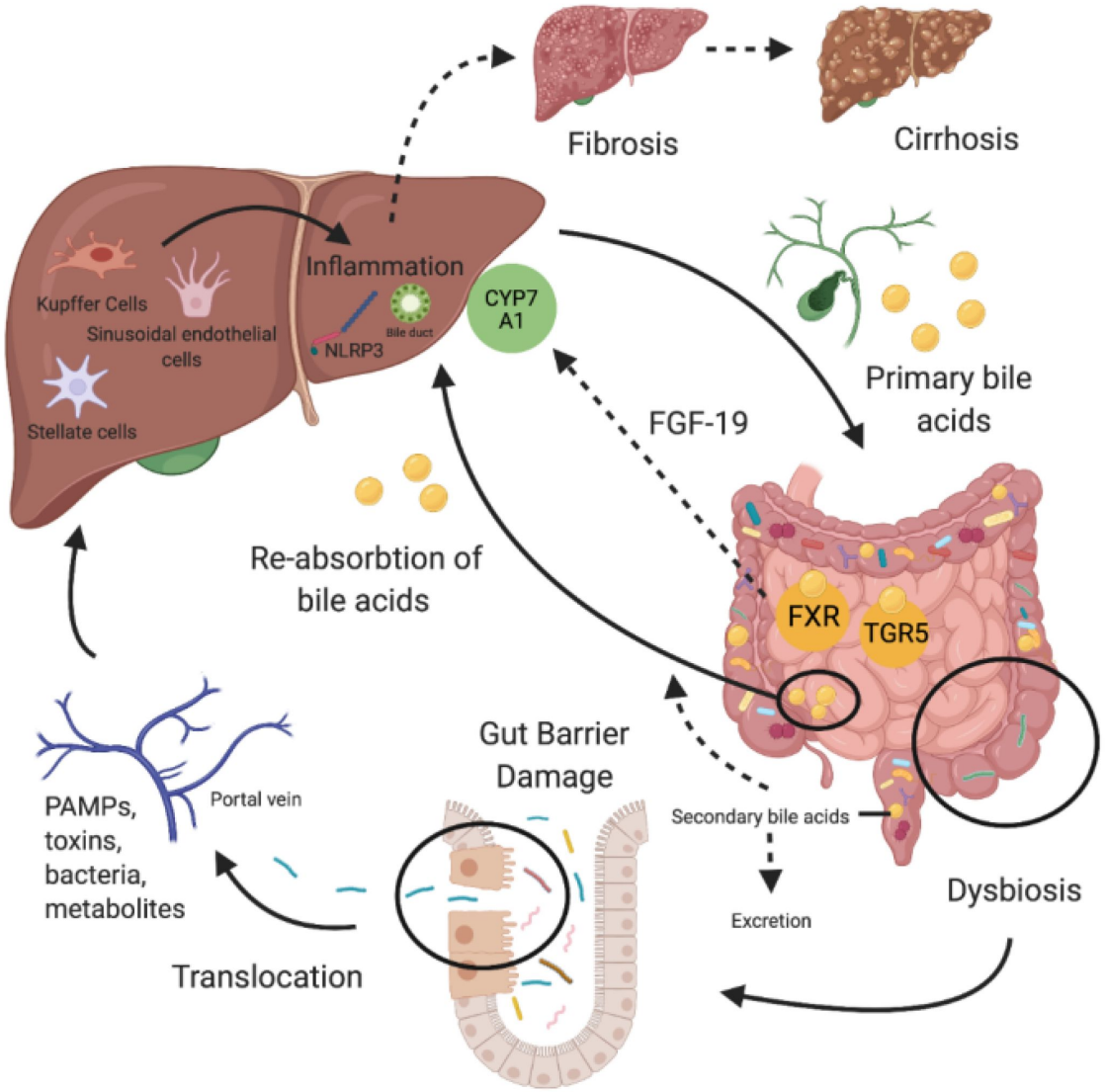
Liver Diseases

Gut-Liver Axis

- Dysbiosis → Gut barrier damage → increased intestinal permeability → **gut-derived toxins (LPS, lipopolysaccharide) → enter the portal circulation → liver**
  - Inflammatory response
  - Activation of immune cells and cytokine release
  - Progression to liver fibrosis, cirrhosis

FMT

- **Suppression of LPS-producing bacteria** → reduces endotoxin influx to the liver → alleviates hepatic inflammation
- Increased production of SCFAs → anti-inflammatory effects, immune regulation
- Modulation of bile acid metabolism
- Management of HE → decreases ammonia-producing bacteria



Clinical Application of FMT

Liver Diseases

Indication

- Elevated liver enzymes of unknown origin
- Chronic hepatitis or cirrhosis
- Hyperammonemia, hepatic encephalopathy
- Poor response to standard hepatic support (SAMe, Silymarin, hepatic diet)

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MINIREVIEWS

Role of fecal microbiota transplant in management of hepatic encephalopathy: Current trends and future directions

Yash R Shah, Hassam Ali, Angad Tiwari, David Guevara-Lazo, Natalia Nombera-Aznaran, Bhanu Siva Mohan Pinnam, Manesh Kumar Gangwani, Harishankar Gopakumar, Amir H Sohail, SriLakshmiDevi Kanumilli, Ernesto Calderon-Martinez, Geetha Krishnamoorthy, Nimish Thakral, Dushyant Singh Dahiya

biomedicines

MDPI

Review

Fecal Microbiota Transplantation in Liver Cirrhosis

Adrian Boicean [1,2], Victoria Birlutiu [1,2], Cristian Ichim [1,2,*], Olga Brusnic [3] and Danusia Maria Onișor [3]

Clinical Application of FMT

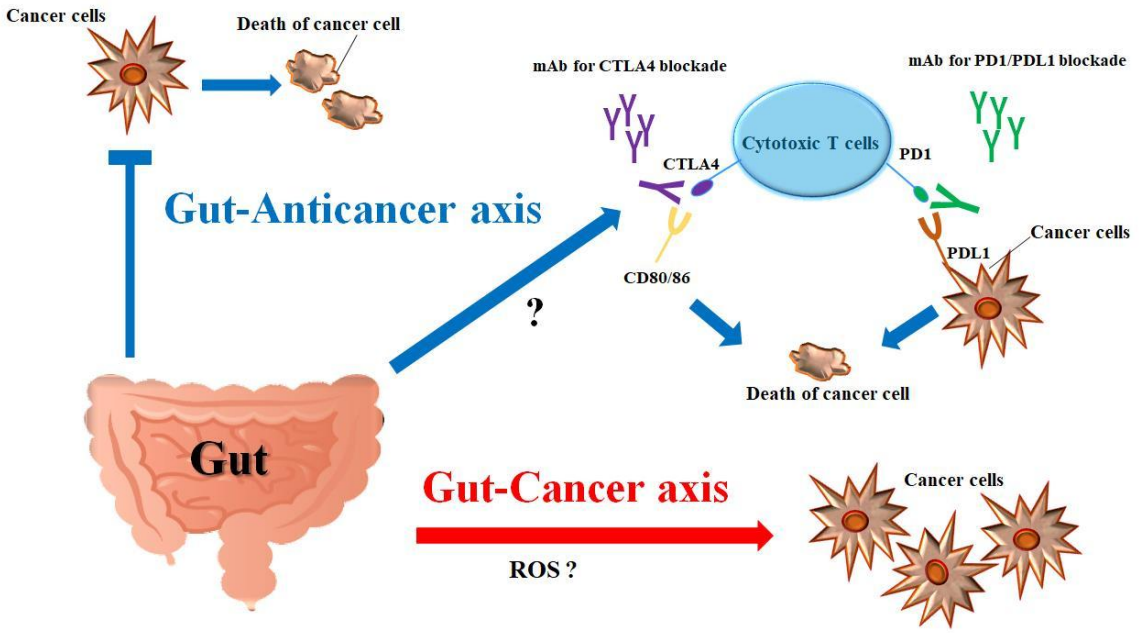
Cancer

Gut-Cancer Axis

- Dysbiosis → chronic inflammation → **carcinogenesis**
- Loss of beneficial microbes → weakened anti-tumor immunity
- Intestinal barrier damage → leaky gut → endotoxins (LPS) translocate into circulation → systemic inflammation
- Chemoresistance microbiota → therapeutic efficacy ↓, side effects ↑

FMT

- Restores microbial balance → reduces inflammation, stabilizes immune function
- SCFAs production ↑ → reduce neuroinflammation, protect neurons
- Improves intestinal barrier integrity → reduces anxiety, stabilizes mood, lowers seizure sensitivity
- Restores immune cell function → normalize the tumor immune microenvironment
- Improves response to cancer therapy, enhance antitumor immunity



Clinical Application of FMT

Cancer

Indication

- Severe **GI side effects** (diarrhea, inappetence, colitis) during chemotherapy
- **Immunosuppression** leading to recurrent or chronic **infection/inflammation**
- Poor or rapidly progressing **response to cancer therapy**
- High risk of **dysbiosis** due to repeated antibiotics, polypharmacy, or advanced age

Therapeutic value of FMT

- **Resets the intestinal ecosystem** and restores **systemic homeostasis**
- Enhances **immune function**, **alleviates side effects**, and **regulates inflammation**
- Supports improved **clinical condition**, better **treatment response**, and enhanced **quality of life**

Thank you