Predictive Value of NKILA and Inc13 lnc RNAs for Distinguishing of Celiac Disease and IBD: A Case-Control Study

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Abstract: Long non-coding RNA 13 (Inc13) and NF-κB-interacting IncRNA (NKILA) are long non-coding RNAs (lncRNAs) that play a role in inflammatory disorders pathogenesis. This study aimed at investigating the expression of these lncRNAs in inflammatory bowel disease (IBD) and celiac disease (CeD) patients compared to controls. We evaluated mRNA expression of Inc13 and NKILA in peripheral blood and intestinal biopsy samples of 50 CeD, 46 IBD patients, and 20 controls using qRT-PCR method. Compared to the controls, CeD and IBD patients had a significantly higher PBMC mRNA level of Lnc13 (p < 0.0001 for both of them) and NKILA (p < 0.0001 and p=0.0174, respectively). NKILA mRNA level was significantly higher in CeD than in IBD patients (p < 0.0001). IBD subjects had significantly increased colonic NKILA expression (p=0.004). In UC, NKILA, and CD, Inc13 colonic expression was significantly increased compared to others (p=0.002 and p=0.0111 respectively for UC, p = 0.0075 and p = 0.002, respectively for CD). Collectively, increased peripheral expression of Inc13 and NKILA along with their decreased duodenal expression demonstrates CeD. Moreover, suppose the increased peripheral expression of Inc13 and NKILA is associated with increased Inc13 colonic expression. In that case, it indicates CD, and if it is associated with increased NKILA colonic expression, it indicates UC.

Keywords: celiac diseases; inflammatory bowel diseases; long noncoding; intestines; blood.

1. Introduction

Inflammatory bowel disease (IBD) is a term for a multifactorial disease that refers to two various inflammatory intestinal disorders, Crohn's disease (CD) and ulcerative colitis (UC) [1-4]. In fact, IBD is an immunologic disturbance that both dysregulated innate and adaptive immune pathways that play an essential role in the disease pathogenesis [5, 6]. IBD is demonstrated in persons with genetic predisposition, but its etiology remains unclear [7].

On the other hand, Celiac disease (CeD) is an autoimmune-mediated disease of the upper small intestine, triggered by the ingestion of gluten-containing grains (including wheat,
rye, and barley) in genetically predisposed persons, that results in small intestinal injury [8,9]. It has been suggested that in CeD, like many autoimmune disorders, the complex interaction between innate and adaptive immunity is the main cause of the disease progression [10-13].

Various studies indicated that IBD and CeD have overlapped, and the coexistence of these two disorders in the same patients has already been described [14-16].

Nuclear factor-kappa B (NF-κB) is an inducible transcription factor that plays a relevant role in modulating the immune and inflammatory responses in the intestinal mucosa [17,18]. Increased NF-κB signaling leads to the development of chronic inflammatory disorders [17,19-22]. Various studies have shown that NF-κB has an increased and persistent expression level in IBD and CeD patients and plays a significant role in the pathogenesis process of these two disorders [19,20,23-28].

Long noncoding RNA 13 (lnc13) and NF-κB-interacting lncRNA (NKILA) are long noncoding RNAs (lncRNAs) that interact with NF-κB and can play a role in inflammatory disorders [29-32].

Lnc13 can maintain intestinal immune homeostasis and keep inflammation down under basal conditions [30]. In response to inflammatory stimuli and after NF-κB activation, Decapping enzyme 2 (DCP2) can degrade lnc13, which leads to dysregulation of lnc13 expression or function [29,30].

Moreover, NKILA is another lncRNA, which is upregulated by NF-κB and found to confine NF-κB-driven inflammation by prevention of the translocation of NF-κB to the nucleus and gene expression. Therefore, it can inhibit inflammatory signaling in this way [31,33].

We hypothesized that lnc13 and NKILA could be used as biomarkers for IBD and CeD assessment and conducted this study to investigate their expression in peripheral blood and intestinal biopsy samples of diagnosed IBD and CeD patients compared to healthy controls by real-time PCR method.

2. Materials and Methods

2.1. Study subjects.

A total of 96 patients had CeD (n=50) and IBD (CD=16, UC=30) and were admitted by the Research Institute for Gastroenterology and Liver Diseases at the Taleghani Hospital (Tehran, Iran) during 2019 were enrolled in this study. Twenty healthy individuals without any clinical evidence of autoimmune disorders were also selected as a control group.

Each CeD patient was untreated and had not received a gluten-free diet before participating in our study. Also, newly IBD diagnosed patients who had not received any treatment participated in this study.

Patients with complete medical records and pathological diagnosis of the disease (endoscopy and duodenal biopsy compatible with serological results for CeD and colonoscopy and biopsy specimens compatible with clinical findings for IBD) and willingness to participate in the research were included in this study. In addition, patients who had other autoimmune diseases, those who used any prohibited medications, and those who failed to cooperate with researchers were excluded.

Healthy individuals who had no current or prior history of gastrointestinal disorders, females who were not pregnant, with willingness of participating enrolled in our study.

This study was performed in accordance with the ethical guidelines of the 1975 Declaration of Helsinki. As well, this study was approved by the Ethics Committee of the
Research Institute for Gastroenterology and Liver Diseases (RIGLD), Shahid Beheshti University of Medical Sciences, Tehran, Iran (IR.SBMU.RIGLD.REC.1395.3). All participants signed an informed written consent form.

Basic information of studied groups is mentioned in Table 1.

| variable | IBD (Blood/Tissue) | Celiac (Blood/Tissue) | Control (Blood/Tissue) |
|----------|---------------------|-----------------------|------------------------|
| Age (mean ± SD) | | | |
| UC | 33.10±14.63 | 37.84±13.960 | 27.95±4.211 |
| CD | 33.90±12.84 | | |
| BMI (mean ± SD) | | | |
| UC | 21.74±14.63 | 24.45±9.442 | 25.008±4.859 |
| CD | 24.02±12.84 | | |
| Gender | | | |
| Male | UC | 15 (68.18%) | 19 (38.0%) | 5 (25.0%) |
| | CD | 7 (31.81%) | | |
| Female | UC | 15 (62.5%) | 31 (62.0%) | 15 (75.0%) |
| | CD | 9 (37.5%) | | |

2.2. Sample collection.

10 ml peripheral blood samples and mucosal biopsy specimens (duodenal biopsy for CeD and colon biopsy for IBD assessment) were collected from studied groups.

2.3. RNA Extraction & cDNA synthesis.

In brief, total RNA was extracted from PBMC and biopsy samples by Qiagen RNA extraction kit (AllPrep DNA/RNA/miRNA Universal Kit) according to the manufacturer’s protocol. The concentration and purity of extracted RNA were determined by Nanodrop spectrophotometer (Thermo Fisher Scientific). RevertAid First Strand cDNA Synthesis kit (Thermo Fisher Scientific) was also used for reverse transcription.

2.4. Quantitative real-time PCR (RT-qPCR).

RT-qPCR was performed on a Rotor-Gene Q real-time PCR system (QIAGEN) using SYBR Green Real-time PCR Master Mix (Takara) kit instruction. Expression of lnc13 and NKILA was normalized to β2-Microglobulin (B2M) according to the \(2^{-\Delta\Delta Ct}\) method. The gene-specific primers sequences are shown in Table 2.

2.5. Statistical analysis.

Statistical analysis was carried out using SPSS (V.21) and GraphPad, Prism (V.6) software. Comparisons between the groups were examined by t-TEST and ANOVA. P-value < 0.05 was considered statistically significant.
3. Results and Discussion

3.1. Evaluation of NKILA mRNA expression.

We measured the expression of NKILA in the duodenal mucosa and PBMC of CeD patients compared to the control group using RT-qPCR. Figure 1A shows that the expression of NKILA was significantly upregulated in PBMC of CeD patients relative to controls (p < 0.0001). On the other hand, as illustrated in Figure 1B, duodenal NKILA IncRNA was significantly down-regulated in CeD patients than in healthy controls (p < 0.0001).

In IBD group, PBMC levels of NKILA IncRNA were significantly higher compared to controls (p=0.0174) (Figure 2A). In fact, this significant up-regulation was seen in both UC and CD patients compared to healthy controls (p < 0.0001 for both of them). However, this difference was not significant when we compared the NKILA expression between UC and CD patients (p > 0.05) (Figure 2B). In addition, NKILA gene expression has a significant up-regulation in the colonic mucosal specimens of IBD patients relative to controls (p=0.004) (Figure 2C). Between IBD patient's groups, UC patients showed significant up-regulation of colonic NKILA gene expression compared to CD patients and controls (p=0.002 and p=0.0111 respectively) (Figure 2D).

Figure 1. NKILA gene expression analysis in CeD patients compared to the control group. (A) mRNA expression in PBMC; (B) mRNA expression in duodenal tissue.

Figure 2. NKILA gene expression analysis in IBD patients compared to the control group. (A) and (B) mRNA expression in PBMC; (C) and (D) mRNA expression in colonic tissue.
3.2. Evaluation of lnc13 mRNA expression.

Regarding the mRNA expression of lnc13, the current result revealed that lnc13 was significantly overexpressed in the PBMC of CeD patients compared with healthy controls (p < 0.0001) (Figure 3A). In contrast, its expression was significantly lower in duodenal biopsy samples of CeD patients compared with controls (p < 0.0001) (Figure 3B).

![Figure 3](https://biointerfaceresearch.com/)

**Figure 3.** Lnc13 gene expression analysis in CeD patients compared to the control group. (A) mRNA expression in PBMC; (B) mRNA expression in duodenal tissue.

By comparing relative lnc13 mRNA levels of IBD patients versus healthy controls, we found that lnc13 was significantly upregulated in patients' PBMC specimens (p < 0.0001) (Figure 4A). High expression was also observed in both UC and CD patients compared to the control group (p < 0.0001 for both of them). Nevertheless, there was not any significant difference between the CD and UC groups (p > 0.05) (Figure 4B).

In addition, IBD patients' colonic lnc13 expression was higher than controls; however, this difference was non-significant (p > 0.05) (Figure 4C). On the other hand, among the IBD group, CD patients had significantly higher colonic expression levels of lnc13 compared to both UC patients and healthy controls (p = 0.0075 and p = 0.002, respectively) (Figure 4D).

![Figure 4](https://biointerfaceresearch.com/)

**Figure 4.** Lnc13 gene expression analysis in IBD patients compared to control group. (A) and (B) mRNA expression in PBMC; (C) and (D) mRNA expression in colonic tissue.
A comparison of the expression of these two lncRNAs between patients with CeD and IBD showed that NKILA mRNA expression was significantly down-regulated in the tissue of CeD compared to IBD patients (p < 0.0001) (Figure 5A). On the other hand, this mRNA expression was significantly upregulated in the PBMC of CeD patients relative to IBD subjects (p < 0.0001) (Figure 5B).

In addition, a significantly lower intestinal level of lnc13 was observed in the CeD patients' group than in the IBD patients (p < 0.0001) (Figure 6A). However, despite a higher expression of lnc13 in CeD patients' PBMC, the difference was non-significant (p > 0.05) (Figure 6B).

As far as we know, this is the first study to investigate the expression profile of lnc13 and NKILA long noncoding RNAs in diagnosed CeD and IBD patients in comparison to controls. The basis of selecting these two lncRNAs for the current study was their association with the NF-κB transcription factor [30,31,33].

NF-κB plays an important role in modulating inflammatory responses in the intestinal mucosa, and its increased and persistent signaling leads to the CeD and IBD development [17,19,20,23-27,35,36]. Lnc13 is an immune homeostasis mediator that increased activation of NF-κB leads to degradation and function dysregulation of this lncRNA [29-31]. Moreover, NKILA is a suppressor of NF-κB-driven inflammation, which NF-κB upregulates, and its degradation results in increased NF-κB expression and further Lnc13 suppression [31,33,37-39].
The results of this study showed that the expression of both lnc13 and NKILA long noncoding RNAs significantly increased in the PBMC of CeD (p < 0.0001 for both of them) and IBD (p < 0.0001 and p=0.0174, respectively) patients than controls and, also this significant overexpression was seen in both CD and UC patients (p < 0.0001 for both of them). It is noteworthy that the expression of NKILA in CeD patients' PBMC was significantly higher than in IBD patients (p < 0.0001).

We also found that these two lncRNAs had a significantly lower expression in celiac disease patients' intestinal tissue samples than IBD patients and control subjects (p < 0.0001). This finding is consistent with the result of the study by Castellanos-Rubio and his colleagues [30] in 2016, which reported a considerable down-regulation of lnc13 in the CeD patient's small bowel biopsy samples compared to that in healthy controls. To date, the study of Castellanos-Rubio et al. [30] is the only investigation that has explored the alteration of lnc13 RNA expression between celiac disease patients and the healthy group. However, they did not investigate the lnc13 expression in the blood [30].

On the other hand, of our two targeted lncRNAs, only the NKILA had significantly increased expression in intestinal tissue specimens of IBD patients compared to the healthy controls (p=0.004).

A key original finding from the present study is that, in UC, NKILA, and CD, lnc13 colonic expression was significantly increased compared to the other studied groups (P<0.05).

Decreased expression of lnc13 in the duodenal specimens of celiac disease patients can be justified through its degradation by DCP2 enzyme in the pathogenesis process as Castellanos-Rubio et al. [30] have pointed out in their study that the expression of DCP2 was increased in CeD patient's biopsy samples compared to controls and DCP2 expression had a converse correlation with the level of lnc13 [29,30]. Since lnc13 keeps inflammation down under basal conditions, this decrease in lnc13 level can lead to the progression of inflammation in CeD patients [30]. On the other hand, lnc13 increased expression in CD patients may be a sign of its effort to suppress inflammation.

Furthermore, studies have shown that intestinal fibrosis is an insoluble and undeniable problem caused by chronic inflammation in IBD patients. Since the TGF-β signaling pathway via Smads has a central role in IBD intestinal fibrosis progression and NKILA can be directly activated by this signaling pathway, it can be concluded that colonic overexpression of NKILA in IBD patients may be a sign of intestinal fibrosis formation in studied patients [40,41].

Studies have also shown that NKILA can function as a tumor suppressor in various cancer types by inhibiting tumor cell proliferation and migration. In fact, NKILA overexpression can inhibit cancer growth, and it is usually downregulated during tumor progression [42-44]. IBD patients are at a significantly increased risk of colorectal cancer (CRC), which is the important cause of global cancer-associated mortality [45,46]. Jian Huang and colleagues [44] reported reduced NKILA expression in patients with colon cancer through the suppressed activity of the PI3K/Akt pathway. Therefore, it can be concluded that colonic overexpression of NKILA in IBD patients, especially in UC group, can be due to its attempt to suppress the growth of colon cancer in these patients.

On the other hand, as mentioned earlier, NKILA is involved in the suppression of NF-κB-induced inflammation, which has been reported to be increased during CeD pathogenesis [19]. Therefore, it can be supposed that a reason for increased NF-κB-triggered inflammation in CeD patients could be a decrease in the NKILA intestinal expression level.
Moreover, it has been reported that lncRNAs are expressed in many different human cell lines and have a PBMC overexpression in diverse autoimmune disorders. For instance, Song et al. [47] reported increased PBMC expression of HOTAIR (HOX transcript antisense RNA) lncRNA in patients with rheumatoid arthritis than healthy controls. Likewise, NEAT1 (Nuclear enriched abundant transcript 1) lncRNA upregulation was reported in PBMCs of systemic lupus erythematosus patients compared to healthy subjects by Zhang et al. [48]. As a result, it can be considered that NKILA and lnc13 are two lncRNAs that have overexpression in CeD and IBD patients PBMC.

4. Conclusions

In conclusion, our data corroborate and further expand the Rubio et al. [30] reports of lnc13 duodenal expression in CeD patients and also provides important and novel basic knowledge in this context. However, there are still important ambiguous points that need to be evaluated. Given the variations in the expression of these lncRNAs between the two groups of patients, it has been hypothesized that these lncRNAs may emerge as novel biomarkers to be evaluated in the IBD and CeD patients' intestinal tissue and PBMC samples for differential diagnostic targets. Accordingly, we considered a hypothetical diagnostic chart for differentiating these diseases, which is shown in Figure 7. Based on this diagnostic chart, it can be considered that increased peripheral expression of lnc13 and NKILA, along with decreased duodenal expression of them, demonstrates celiac disease. On the other hand, if the increased peripheral expression of lnc13 and NKILA is associated with increased lnc13 colonic expression, it indicates Crohn's disease. If it is associated with increased NKILA colonic expression, it indicates ulcerative colitis. But its validation and extension require further studies with the same results.

![Figure 7. Hypothetical diagnostic chart for differentiating IBD and CeD.](image)

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Conflicts of Interest

The authors declare no conflict of interest.

References

1. Kaser, A.; Zeissig, S.; Blumberg, R.S. Inflammatory bowel disease. Annu Rev Immunol 2010, 28, 573-621, https://doi.org/10.1146/annurev-immunol-030409-101225.
2. Nakase, H.; Uchino, M.; Shinzaki, S.; Matsuura, M.; Matsuoka, K.; Kobayashi, T.; Saruta, M.; Hirai, F.; Hata, K.; Hiraoka, S.; Esaki, M.; Sugimoto, K.; Fuji, T.; Watanabe, K.; Nakamura, S.; Inoue, N.; Itoh, T.; Naganuma, M.; Hisamatsu, T.; Watanabe, M.; Miwa, H.; Enomoto, N.; Shimosegawa, T.; Koike, K. Evidence-based clinical practice guidelines for inflammatory bowel disease 2020. J Gastroenterol 2021, 56, 489–526, https://doi.org/10.1007/s00535-021-01784-13.
3. Zhao, M.; Gönczi, L.; Lakatos, P.L.; Burisch, J. The Burden of Inflammatory Bowel Disease in Europe in 2020. J Crohns Colitis 2021, https://doi.org/10.1093/ecco-jcc/jjab029.
4. Roda, G.; Chien Ng, S.; Kotze, P.G.; Argollo, M.; Panaccione, R.; Spinelli, A.; Kaser, A.; Peyrin-Biroulet, L.; Danese, S. Crohn's disease. Nat Rev Dis Primers 2020, 6, 22, https://doi.org/10.1038/s41572-020-0156-2.
5. Segal, J.P.; LeBlanc, J-F.; Hart, A.L. Ulcerative colitis: an update. Clin Med 2021, 21, 135-139, https://doi.org/10.7861/clinmed.2021-0080.
6. Siegmund, B.; Zeitz, M. Innate and adaptive immunity in inflammatory bowel disease. World J Gastroenterol 2011, 17, 3178-3183, https://doi.org/10.3748/wjg.v17.i27.3178.
7. Liu, T-C.; Stappenbeck, T.S. Genetics and Pathogenesis of Inflammatory Bowel Disease. Annu Rev Pathol 2016, 11, 127-148, https://doi.org/10.1146/annurev-pathol-012615-044152.
8. McGough, N.; Cummings, J.H. Coeliac disease: a diverse clinical syndrome caused by intolerance of wheat, barley and rye. Proc Nutr Soc 2005, 64, 434-450, https://doi.org/10.1079/pns2005461.
9. Rostami Nejad, M.; Karkhane, M; Marzban, A; Nazemalhosseini Mojarad, E.; Rostami, K. Gluten related disorders. Gastroenterol Hepatol Bed Bench 2012, 5, S1-S7.
10. Lopez Casado, M.A.; Lorite, P.; Ponce de Leon, C.; Palomeque, T.; Torres, M.I. Celiac Disease Autoimmunity. Arch Immunol Ther Exp (Warsz) 2018, 66, 423-430, https://doi.org/10.1007/s00005-018-0520-z.
11. Rostami-Nejad, M. Immunology of celiac disease focused on vaccine therapy. Int J Celiac Dis 2015, 3, 115-117, https://doi.org/10.12691/ijcd-3-4-4.
12. Asri, N.; Rostami-Nejad, M. The Facts of Celiac Disease: A Comprehensive Review. Int J Celiac Dis 2019, 7, 48-52, https://doi.org/10.12691/ijcd-7-2-7.
13. Scherf, K.A.; Catassi, C.; Chirdo, F.; Ciclitira, P.J.; Feigheary, C.; Gianfrani, C.; Koning, F.; Lundin, K.E.A.; Schuppan, D.; Smulders, M.J.M. et al. Recent Progress and Recommendations on Celiac Disease From the Working Group on Prolamin Analysis and Toxicity. Front Nutr 2020, 7, 29, https://doi.org/10.3389/fnut.2020.00029.
14. Shah, A.; Walker, M.; Burger, D.; Martin, N.; von Wulffen, M.; Koloski, N.; Jones, M.; Talley, N.J.; Holtmann, G.J. Link between celiac disease and inflammatory bowel disease. J Clin Gastroenterol 2019, 53, 514-522, https://doi.org/10.1097/MCG.0000000000001033.
15. Tse, C.; Deepak, P.; de La Fuente, J.; Murray, J.; Papadakis, K. P616 Natural history and phenotype of inflammatory bowel disease with co-existent celiac disease. J Crohns Colitis 2017, 11, S394-S395, https://doi.org/10.1016/S0165-5085(17)31508-1.
16. Rostami-Nejad, M.; Sadeghi, A.; Asadzadeh-Aghdæi, H.; Rismantab, S.; Zali, M.R. Gluten-free diet for refractory inflammatory bowel disease; a case report. Int J Celiac Dis 2017, 5, 168-170, https://doi.org/10.12691/ijcd-5-4-4.
17. Liu, T.; Zhang, L.; Joo, D.; Sun, S.-C. NF-kB signaling in inflammation. *Signal Transduct Target Ther* **2017**, 2, 17023, https://doi.org/10.1038/s41592-017-0314-z.

18. Zinatizadeh, M.R.; Schock, B.; Chalhatani, G.M.; Zarandi, P.K.; Jalali, S.A.; Miri, S.R. The Nuclear Factor Kappa B (NF-kB) signaling in cancer development and immune diseases. *Genes & Diseases* **2021**, 8, 287-297, https://doi.org/10.1016/j.gendis.2020.06.005.

19. Fernandez-Jimenez, N.; Castellanos-Rubio, A.; Plaza-Izurieta, L.; Irastorza, I.; Elcoroaristizabal, X.; Jauregi-Miguel, A.; Lopez-Euba, T.; Tutau, C.; de Pancorbo, M.M.; Vitoria, J.C.; Bilbao, J.R. Coregulation and modulation of NFκB-related genes in celiac disease: uncovered aspects of gut mucosal inflammation. *Hum Mol Genet* **2014**, 23, 1298-1310, https://doi.org/10.1093/hmg/ddt520.

20. Schreiber, S.; Nikolaus, S.; Hampe, J. Activation of nuclear factor kB in inflammatory bowel disease. *Gut* **1998**, 42, 477-484, https://doi.org/10.1136/gut.42.4.477.

21. Yu, H.; Lin, L.; Zhang, Z.; Zhang, H.; Hu, H. Targeting NF-kB pathway for the therapy of diseases: mechanism and clinical study. *Signal Transduct Target Ther* **2020**, 5, 209, https://doi.org/10.1038/s41392-020-00312-6.

22. Zhou, J.; Zhou, Q.; Zhang, T.; Fan, J. C7ORF41 Regulates Inflammation by Inhibiting NF-kB Signaling Pathway. *Biomed Res Int* **2021**, 2021, 7413605, https://doi.org/10.1155/2021/7413605.

23. Neurath, M.; Becker, C.; Barbulescu, K. Role of NF-kB in immune and inflammatory responses in the gut. *Gut* **1998**, 43, 856-860, https://doi.org/10.1136/gut.43.6.856.

24. Mairi, M.C.; De Stefano, D.; Mele, G.; Fecarotta, S.; Greco, L.; Troncone, R.; Carnuccio, R. Nuclear factor κB is activated in small intestinal mucosa of celiac patients. *J Mol Med. (Berl)* **2003**, 81, 373-379, https://doi.org/10.1007/s00109-003-0440-0.

25. Loncar, M.; Al-Azzeh, E.; Sommer, P.S.; Marinovic, M.; Schmehl, K.; Kuschewski, M.; Blin, N.; Stohwasser, R.; Gött, P.; Kayademir, T. Tumour necrosis factor α and nuclear factor κB inhibit transcription of human TFF3 encoding a gastrointestinal healing peptide. *Gut* **2003**, 52, 1297-1303, https://dx.doi.org/10.1136/gut.52.9.1297.

26. Kuryłowicz, A.; Nauman, J. The role of nuclear factor-kappaB in the development of autoimmune diseases: a link between genes and environment. *Acta Biochim Pol* **2008**, 55, 629-647, https://doi.org/10.18388/abp.2008_3023.

27. Ferretti, G.; Bacchetti, T.; Masciangelo, S.; Saturni, L. Celiac disease, inflammation and oxidative damage: a nutrigenetic approach. *Nutrients* **2012**, 4, 243-257, https://doi.org/10.3390/nu4040243.

28. Lu, P.-D.; Zhao, Y.-H. Targeting NF-kB pathway for treating ulcerative colitis: comprehensive regulatory characteristics of Chinese medicines. *Chin Med* **2020**, 15, 15, https://doi.org/10.1186/s13020-020-0296-z.

29. Ghosh, S.; Castellanos-Rubio, A. Disease-associated SNPs in inflammation-related IncRNAs. *Front Immunol* **2019**, 10, 420, https://doi.org/10.3389/fimmu.2019.00420.

30. Castellanos-Rubio, A.; Fernandez-Jimenez, N.; Kratchmarov, R.; Luo, X.; Bhagat, G.; Green, P.H.; Schneider, R.; Kiledjian, M.; Bilbao, J.R.; Ghosh, S. A long noncoding RNA associated with susceptibility to celiac disease. *Science* **2016**, 352, 91-95, https://doi.org/10.1126/science.aad30467.

31. Mathy, N.W.; Chen, X-M. Long noncoding RNAs (lncRNAs) and their transcriptional control of inflammatory responses. *J Biol Chem* **2017**, 292, 12375-12382, https://doi.org/10.1074/jbc.R116.760884.

32. Jafari, D.; Noorbakhsh, F.; Delavari, A.; Tavakkoli-Bazzaz, J.; Farashi-Bonah, S.; Abdollahzadeh, R.; Rezaei, N. Expression level of long noncoding RNA NKLAMiR103-miR107 inflammatory axis and its clinical significance as potential biomarker in patients with colorectal cancer. *J Res Med Sci* **2020**, 25, 41, https://doi.org/10.4103/jrms.JRMS_94_19.

33. Liu, B.; Sun, L.; Liu, Q.; Gong, C.; Yao, Y.; Lv, X.; Lin, L.; Yao, H.; Su, F.; Li, D.; Zeng, M.; Song, E. A cytoplasmic NF-kB interacting long noncoding RNA blocks 1kB phosphorylation and suppresses breast cancer metastasis. *Cancer Cell* **2015**, 27, 370-381, https://doi.org/10.1016/j.ccell.2015.02.004.

34. Safari, M.T.; Chaleshi, V.; Tarban, P.; Nourian, M.; Balaii, H.; Shahrokhi, S.; Aghdae, H.A. Evaluation of IL-17B and IL-17F mRNA expression in peripheral blood mononuclear cells and association with clinical outcome of IBD patients. *Gastroenterol Hepatol Bed Bench.* **2017**, 10, S79-S80.

35. Peng, C.; Ouyang, Y.; Lu, N.; Li, N. The NF-kB Signaling Pathway, the Microbiota, and Gastrointestinal Tumorigenesis: Recent Advances. *Front Immunol* **2020**, 11, 1387, https://doi.org/10.3389/fimmu.2020.01387.

36. Zhou, Y.; Cui, C.; Ma, X.; Luo, W.; Zheng, S.G.; Qiu, W. Nuclear Factor κB (NF-κB)-Mediated Inflammation in Multiple Sclerosis. *Front Immunol* **2020**, 11, 391, https://doi.org/10.3389/fimmu.2020.00391.
37. Bocchetti, M.; Scrima, M.; Melisi, F.; Luce, A.; Sperlongano, R.; Caraglia, M.; Zappavigna, S.; Cosso, A.M. LncRNAs and Immunity: Coding the Immune System with Noncoding Oligonucleotides. *Int J Mol Sci* 2021, 22, 1741, https://doi.org/10.3390/ijms22041741.

38. Wang, H.; Liu, Y.; Huan, C.; Yang, J.; Li, Z.; Zheng, B.; Wang, Y.; Zhang, W. NF-κB-Interacting Long Noncoding RNA Regulates HIV-1 Replication and Latency by Repressing NF-κB Signaling. *J Virol* 2020, 94, e01057-20, https://doi.org/10.1128/JVI.01057-20.

39. Ghafouri-Fard, S.; Abak, A.; Fattahi, F.; Hussen, B.M.; Bahroudi, Z.; Shoorei, H.; Taheri, M. The interaction between miRNAs/lncRNAs and nuclear factor-κB (NF-κB) in human disorders. *Biomed Pharmacother* 2021, 138, 111519, https://doi.org/10.1016/j.biopha.2021.111519.

40. Yun, S.-M.; Kim, S.-H.; Kim, E.-H. The Molecular Mechanism of Transforming Growth Factor-β Signaling for Intestinal Fibrosis: A Mini-Review. *Front Pharmacol* 2019, 10, 162, https://doi.org/10.3389/fphar.2019.00162.

41. Lu, Z.; Li, Y.; Wang, J.; Che, Y.; Sun, S.; Huang, J.; Chen, Z.; He, J. Long noncoding RNA NKILA inhibits migration and invasion of non-small cell lung cancer via NF-kappaB/Snail pathway. *J Exp Clin Cancer Res* 2017, 36, 54, https://doi.org/10.1186/s13046-017-0518-0.

42. Ke, S.; Li, R.-C.; Meng, F-K.; Fang, M.-H. NKILA inhibits NF-κB signaling and suppresses tumor metastasis. *Aging (Albany NY)* 2018, 10, 56-71, https://doi.org/10.18632/aging.101359.

43. Wu, W.; Chen, F.; Cui, X.; Yang, L.; Chen, J.; Zhao, J.; Huang, D.; Liu, J.; Yang, L.; Zeng, J. & al. LncRNA NKILA suppresses TGF-β-induced epithelial-mesenchymal transition by blocking NF-κB signaling in breast cancer. *Int J Cancer* 2018, 143, 2213-2224, https://doi.org/10.1002/ijc.31605.

44. Huang, J.; Zhao, L.; Chen, W.; Duan, J.; Shrestha, D.; Zhou, R.; Tuo, X.; Zhu, Z. LncRNA NKILA suppresses colon cancer cell proliferation and migration by inactivating PI3K/Akt pathway. *Transl Cancer Res* 2018, 7, 1431-1438, https://doi.org/10.21037/tcr.2018.11.05.

45. Askling, J.; Linet, M.; Gridley, G.; Halstensen, T.S.; Ekstrom, K.; Ekbom, A. Cancer incidence in a population-based cohort of individuals hospitalized with celiac disease or dermatitis herpetiformis. *Gastroenterol* 2002, 123, 1428-1435, https://doi.org/10.1053/gast.2002.36585.

46. Stidham, R.W.; Higgins, P.D.R. Colorectal Cancer in Inflammatory Bowel Disease. *Clin Colon Rectal Surg* 2018, 31, 168-178, https://doi.org/10.1055/s-0037-1602237.

47. Song, J.; Kim, D.; Han, J.; Kim, Y.; Lee, M.; Jin, E.J. PBMC and exosome-derived Hotair is a critical regulator and potent marker for rheumatoid arthritis. *Clin Exp Med* 2015, 15, 121-126, https://doi.org/10.1007/s10238-013-0271-4.

48. Zhang, F.; Wu, L.; Qian, J.; Qu, B.; Xia, S.; La, T.; Wu, Y.; Ma, J.; Zeng, J.; Guo, Q. & al. Identification of the long noncoding RNA NEAT1 as a novel inflammatory regulator acting through MAPK pathway in human lupus. *J Autoimmun* 2016, 75, 96-104, https://doi.org/10.1016/j.jaut.2016.07.012.