DNA Testing Applied to Fibromyalgia Syndrome Analysis and Management

Abstract
The Fibromyalgia syndrome (FMS) is a very complex condition with a relevant clinical heterogeneity. Considering this premise, the present paper interprets this heterogeneity as the result from differences in individual genetic makeup (genetic polymorphisms) and a constant interaction gene-gene and gene-environment. This paper proposed a method based on the detection of a genetic profile as an additional analytical tool to incorporate in a clinical protocol with the aim to individualize the FMS management.

Keywords: Fibromyalgia syndrome (FMS), Genetics, Personalized medicine, DNA-polymorphisms

Abbreviations: FMS: Fibromyalgia Syndrome; CD: Crohn’s Disease; UC: Ulcerative Colitis; IBS: Irritable Bowel Syndrome; COMT: Catechol-o-methyl Transferase

A Genetic Approach to FMS from A Multifactorial Point of View

We know that there is a genetic component for FMS [1]. Different population studies have been performed to identify the causal genes linked to FMS [2,3], but until now there are none which alone explain all the cases, meaning the investigations must continue.

FMS has been long considered as a psychogenic or psychosomatic disease. Most patients are suffering this stigma because they show many symptoms which are too many and too diverse to be considered as a single organic disease. For that reason, it is more appropriate to consider fibromyalgia as a syndrome with a vast heterogeneity in causes as well as in severity of symptoms and clinical evolution. It is a health problem which is very frequent in Spain having a prevalence of 2.4% of the population older than 20 years and being more frequent in women than in men, in a ratio of 21:1. Despite the high prevalence, its etiology remains unknown and no effective treatments exist [4].

Main Mechanisms
There are four mechanisms to consider for a diagnosis and management of FMS (Figure 1):

a. Neurochemistry determining the Neurotransmitter balances.

b. System of enzymatic antioxidants which determine differential vulnerability to environmental toxics.

c. Immune system mediators of Inflammation.

d. Pharmacogenetics.

Figure 1: Four mechanisms to consider for a diagnosis and management of FMS.

Neurochemistry Determining the Neurotransmitter Balance
There are several genetic polymorphisms in genes linked to these mechanisms [5,6]. These genetic polymorphisms determine the variability of expression of them which in turn determines the differences in functional efficiency that lead to a lower or higher probability to develop health complications related to FMS.

We have designed a genetic analysis methodology which encompasses the main genes linked to the different pathways which determine the 4 mechanisms that we proposed to consider in the process of analysis to carry out in FMS (Table 1) [7-37].

It is important to highlight some genes as COMT and IL6 included in our study according to our personal experience [16]. The relevance of these genes has been also corroborated by other authors in different population studies [19].
Genes
Transporters
Phase I Enzymes
Receptors
Gene Function
Metabolism
Enzymes
CYP2D6 [35,36], CYPC9 [35,37], CYP2C19 [35,38]
Immunomodulatory role
Cytokines
Phase II Enzymes
Drug metabolism
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There are many other relevant genes as MAO-A [20] and HTR2A [21,22] also included in our study as well as polymorphisms at adrenergic receptor genes [23], and special immunogenetics leading to a pro-inflammatory status [16-18,34], among others as CYP450 enzymatic polymorphisms which are mainly related to the pain management [35-38].

All these genes are involved in the neurotransmitters balance determining the potential to have excess or defect in any of them. A tendency to show low serotonin levels is quite significant among fibromyalgia patients [39]. Due to several genetic polymorphisms affecting the dopamine and/or serotonin pathways can take place an imbalance (excess of dopamine/serotonin defect) inducing sensitivity to pain, sleep disorders and mood alterations. For this reason the use of anti-depressives is very frequent within the treatment of fibromyalgia, as anti-depressives usually act in a way which increases serotonin levels [40]. The problem arise from the undesirable drug effects which normally accompany most of the antidepressant drugs, something that can even turn out to be damaging in many patients. Being the slow variant of COMT enzyme the most prevalent in FMS patients, there is a tendency to have increased levels of dopamine which might induce some movement disorders (Periodic limb movement disorder and Restless leg syndrome) that have been also reported as comorbidities in some FMS patients [41,42]. The proposed methodology starts with a medical consultation, where an interview is conducted to obtain exhaustive information about the patient personal and family history. As the second step, the procedure for the genetic analysis is explained to obtain the informed consent to proceed. The genetic analysis is always carried out under informed consent guaranteeing data protection and pre-and post-test genetic counseling. Once the genetic analysis of the laboratory is finished, the entire history is analyzed together with the results of the DNA testing. Considering all the information, we design specific measures or intervention strategy and medical follow-up which are based on nutrigenomics and pharmacogenetics.

**Table 1: Genetic Factors Related to FMS Molecular Mechanisms.**

| Molecular Mechanisms                        | Genes                        | Gene Function |
|---------------------------------------------|------------------------------|---------------|
| System of enzymatic antioxidants            | CYP1A1 [7,8], CYP1B1 [7,8,13], SOD2 [9] | Phase I Enzymes |
|                                              | CAT [10], GSTM1 [1,1,12], GSTT1 [1,1,12,14], GSTP1 [1,1,12], SUOX [13], SULT1A1 [14], NAT2 [1,1,15] | Phase II Enzymes |
| Mediators of Inflammation                   | IL6 [16], IL10 [16], TNFα [17] | Cytokines     |
|                                              | VDR [18]                      | Immunomodulatory role |
| Neurochemistry and potential metabolic responses | COMT [19,20], MAOA [20]       | Enzymes        |
|                                              | HTR2A [21,22], ADRA2 [23], DRD2 [24], OPRM1 [25], OXTR [26] | Receptors      |
|                                              | DAT1 [27], SHTT [28]         | Transporters   |
|                                              | APOE [29-31], MTHFR [32,33]  | Metabolism     |
| Pharmacogenetics                            | CYP2D6 [35,36], CYP2C9 [35,37], CYP2C19 [35,38] | Drug metabolism |

Impairment in the Functioning of Phase I and Phase II Enzymatic Detoxifying Systems Which Determine Different Degree of Tolerance to Oxidative Stress

Our organism has diverse enzymatic protection systems against toxic attacks from the environment. These mechanisms also allow us to maintain the homeostasis of endogenous metabolites. The functioning efficiency of each of the enzymes which make up these defense systems (Phase I and Phase II detoxification systems) is genetically determined so diverse genetic polymorphisms exist which codify for such enzymes [7-15].

It has been shown that there is an association between defects in the xenobiotic metabolism gene that code for detoxifying enzymes and the risk of developing diverse human pathologies with clear environmental components, such as the FMS [43-45].

Oxidative stress has also been involved as a primary or secondary occurrence in other diseases. Important data exists relating both to the start and the progression of Parkinson’s, demonstrating the presence of high levels of free radicals in early stages of Huntington’s disease, in renal diseases and Alzheimer’s and several other neurodegenerative diseases [46]. Also, it’s role in the worsening of symptoms in diseases such as hemolytic anemia [47] or amyotrophic lateral sclerosis has been [48]. At this point, it is also relevant its interrelation with another essential mechanism to take in consideration: the aberrant functioning of the immune system.

Increased Tendency to Show an Unbalanced Immune System Functioning With Pro-Inflammatory Preponderance

Recent studies have emphasized the role of the immune system in FM pathogenesis and its comorbidities [16-18]. On the other hand, taking back the previously mentioned mechanism (oxidative stress), It has been demonstrated that high levels of inflammation...
correlate to oxidative stress and mitochondrial dysfunction, at the same time, these levels of inflammation correlate to pain so that more oxidative stress induce more inflammation and at therefore, more pain [49].

There is strong evidence making possible to support the idea that inflammatory process may be contributing to the appearance and progression of FM. Even though classic inflammatory processes were not observed in some FM patients, they display some anomalies related to inflammation. In a previous study, we have corroborated in Spanish FM patients a strong correlation with some pro-inflammatory mediators as interleukin-6 (IL6) and FM clinical severity [16]. In other studies, it has been shown that FMS patients commonly show higher levels than normal of inflammatory mediators (P substance and Corticotrophin-releasing hormone, CRH). In the same way, the serum of patients with fibromyalgia commonly contains higher levels than normal of pro-inflammatory cytokines emphasizing interleukin-6 (IL-6), while fibromyalgia patients’ skin commonly contains higher than normal quantities of mast cells, which can produce IL-6 [50].

Taking back the concept of oxidative stress and its close relationship with immunity, it is relevant to mention that a high level of pro-oxidant molecules (e.g. peroxynitrite) induce the exaggerated increase in inflammatory cytokine levels (IL-1b, IL-6, TNF-a) being more intense in those patients having a genetic susceptibility to an exaggerated releasing of such cytokines. These cytokines, in turn, produce nitric oxide that combines with superoxide to form more peroxynitrite, a situation which finishes perpetuating the cycle and contributing to cellular damage, being especially negative for the health of mitochondria [51]. It is well known that many FMS patients have intestinal health problems. In fact, an excess of pro-inflammatory mediators as IL6 together with low levels of anti-inflammatory mediators like IL10 as we have previously reported in study carried out in FMS [16] may induce an increased intestinal permeability due to a sustained excess of intestinal inflammation. This situation would lead to a disruption of the microbiota balance in favor of an overpopulation of pathogens [52] which, in turn, might induce more inflammation falling into a vicious circle that trigger more serious inflammatory bowel disease (IBD) problems as Crohn’s disease (CD), ulcerative colitis (UC) and (IBS) [53].

Conclusion

CSS encompasses a complex and heterogeneous group of syndromes whose diagnosis is still a challenge for professional health careers. Up to the present, it is only based on clinical criteria without any single confirmatory laboratory test.

Their condition as biologically based disorders have been long discussed and yet not well understood. Nevertheless, there are an increasing number of evidences pointing out to several mechanisms that might be involved in their etiology. Several genetic polymorphisms related to these pathways make possible to carry out a biological characterization by a genotyping process that we have designed as the FibromialGen.

We defined as the main representative causal mechanisms an especial neurobiochemistry and metabolic characteristics in conjunction with an extremely impaired defensive antioxidant capacity and an exaggerated pro-inflammatory tendency. Although the four mechanisms are always present in the biological profile of all CSS types; they act in a different way in each one. According to the preponderance or specific weight of one of them over the set, we might define the most likely type of CSS that we are facing in each analyzed patient.

Recognizing these differences, we might be able to design more effective therapeutic approach because we are acting on biological individualities as targets.

Competing Interest

The author declares that there is no conflict of interests regarding the publication of this paper.

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