

Heterozygosity analysis of polycystic kidney disease 1 gene microsatellite markers for linkage analysis of autosomal dominant polycystic kidney disease type 1 in the Iranian population

Razieh Fatehi¹, Sharifeh Khosravi¹, Maryam Abedi¹, Rasoul Salehi¹, Yousof Gheisari^{1,2}

¹Department of Genetics and Molecular Biology, Isfahan University of Medical Sciences, ²Regenerative Medicine Laboratory, Isfahan Kidney Diseases Research Center, Isfahan University of Medical Sciences, Isfahan, Iran

Background: Autosomal dominant polycystic kidney disease (ADPKD) is the most common genetic cause of end-stage renal disease. Although imaging techniques are a means of accurate diagnosis when the cysts appear in the third or fourth decades of the patient's life, they are of little value for early diagnosis. Genetic tests are required for preimplantation genetic diagnosis, decision-making for kidney donation to an affected relative. Although mutation of the polycystic kidney disease (*PKD1*) gene is solely responsible for the most cases of ADPKD, direct genetic testing is limited by the large size of this gene and the presence of many mutations without hot spots. Therefore, indirect diagnosis with linkage analysis using informative microsatellite markers has been suggested. **Materials and Methods:** In this study, we assessed the informativeness of the *PKD1* gene markers D16S475, D16S291, and D16S3252 in Iranian population. Using specific primers, fluorescent polymerase chain reaction (PCR) was performed on genomic DNA extracted from fifty unrelated individuals. PCR products were analyzed by the ALFexpress DNA sequencer system, and the number and frequency of alleles were determined to calculate the heterozygosity (HET) and polymorphism information content (PIC) values. **Results:** We found that the HET and PIC values for the D16S475 marker are 0.92 and 0.91, respectively. These two values are 0.82 and 0.80 for D16S291 and 0.50 and 0.47 for D16S3252, respectively. **Conclusion:** Based on this data, D16S475 and D16S291 are highly and D16S3252 is moderately informative for indirect genetic diagnosis of *PKD1* mutations in this population.

Key words: Autosomal dominant polycystic kidney disease, linkage analysis, microsatellite markers, polycystic kidney disease 1

How to cite this article: Fatehi R, Khosravi S, Abedi M, Salehi R, Gheisari Y. Heterozygosity analysis of polycystic kidney disease 1 gene microsatellite markers for linkage analysis of autosomal dominant polycystic kidney disease type 1 in the Iranian population. *J Res Med Sci* 2017;22:102.

INTRODUCTION

Autosomal dominant polycystic kidney disease (ADPKD) is a common hereditary kidney disease, with a frequency of 1 in 400–1 in 1000 in the general population.^[1] This progressive disorder is caused by polycystic kidney disease (*PKD*)-1 mutation in 85% of the cases and *PKD*-2 mutation in most of the remaining ADPKD patients.^[2,3] ADPKD is caused by growing cysts in the kidney tubules often leads to renal failure and end-stage renal disease.^[4] Besides the impairment of kidney function, ADPKD

can also affect other organs such as the liver, pancreas, and spleen through the occurrence of growing cysts.^[5] This multisystemic disorder is associated with cerebral and aortic aneurysms which cause sudden death in 8% of the patients.^[6] Typically, ADPKD is diagnosed with the detection of cysts in the kidneys by imaging techniques. However, as the disease is late onset, these techniques are not suitable for diagnosis in children and young adults. Genetic tests allow the early detection of the disease which is important for genetic counseling, preimplantation genetic diagnosis, kidney donation from a young relative, or selection of individuals for

Access this article online

Quick Response Code:



Website:

www.jmsjournal.net

DOI:

10.4103/jrms.JRMS_136_17

This is an open access article distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as the author is credited and the new creations are licensed under the identical terms.

For reprints contact: reprints@medknow.com

Address for correspondence: Dr. Yousof Gheisari, Department of Genetics and Molecular Biology, Isfahan University of Medical Sciences, Isfahan 81746-73461, Iran. E-mail: ygheisari@med.mui.ac.ir

Dr. Rasoul Salehi, Department of Genetics and Molecular Biology, Isfahan University of Medical Sciences, Isfahan 81746-73461, Iran. E-mail: r_salehi@med.mui.ac.ir

Received: 12-02-2017; **Revised:** 08-05-2017; **Accepted:** 20-06-2017

the screening of aneurysms.^[7,8] However, direct mutation detection of this disorder are not straightforward due to the large size of the genes, extensive missense mutations dispersed almost all over the genes, and the existence of *PKD1* homolog parts in the genomes.^[9,10] Therefore, indirect genetic testing based on linkage analysis can be considered for early detection of ADPKD.^[11] This method is highly dependent on the presence of informative markers. Marker informativeness is population dependent and the appropriateness of markers should be assessed in local populations.^[12] The *PKD1* gene region contains different polymorphic markers. Among the microsatellite markers reported in the *PKD1* gene region, two extragenic markers, i.e., D16S475 and D16S291, and one intragenic marker, i.e., D16S3252 have been shown to have a high degree of heterozygosity (HET).^[13-16] However, investigation of these markers has been rarely performed in the Iranian population. In this study, the HET and polymorphism information content (PIC) values for the *PKD1* markers D16S475, D16S291, and D16S3252 were determined in a normal population of Iran.

MATERIALS AND METHODS

Sample preparation and DNA extraction

Peripheral blood samples were obtained from fifty unrelated, healthy individuals in Isfahan, Iran. DNA was extracted using the genomic DNA isolation kit (Genet Bio, Seoul, South Korea) according to the instructions of the manufacturer.

Primer design

The sequences of microsatellite markers were obtained from the ensemble database.^[17] Primers were designed with PrimerPlex 2 V2.5 software (PREMIER Biosoft, Palo Alto CA, USA) for multiplex polymerase chain reaction (PCR) [Table 1]. Primer synthesis and labeling were performed by Macrogen (Seoul, South Korea).

Microsatellite genotyping

Using fluorescent PCR, DNA samples were genotyped for D16S475, D16S291, and D16S3252 with specific

primers. PCR reactions were carried out in total volume of 25 μ l containing 1 mM MgCl₂, 1 unit of Taq DNA polymerase, 2.5 μ l 10X PCR buffer, 0.2 mM dNTP mix (all from CinnaGen, Tehran, Iran), 2 μ l DMSO (85%; MP Biomedicals, Santa Ana, California), 2 μ l glycerol (20% v/v; Merck, Darmstadt, Germany), 5 μ M reverse primer, 5 μ M Cy5-labeled forward primer, and 50 ng genomic DNA. Reaction conditions were as follows: 94°C (5 min), 10 cycles of 94°C (30 s), 68°C (30 s), and 72°C (30 s), followed by 30 cycles of 94°C (30 s), 60°C (30 s), and 72°C (30 s), and then a final extension step at 72°C for 5 min. After an initial examination with 2% agarose gel, the Cy5-labeled PCR products were studied using the automated laser fluorescence ALFexpress system (Amersham, Pharmacia Biotech, Roosendaal, Netherlands) for fragment size analysis.

Data analysis

PowerMarker V3.25 software was applied to perform the subsequent statistical analyses, including allele frequency, observed and expected HET values, PIC value, and testing the Hardy–Weinberg equilibrium (HWE).^[18]

RESULTS

To determine the informative markers for ADPKD1 genetic testing, genotyping of the markers linked to the *PKD1* gene, D16S475, D16S291, and D16S3252, was performed for fifty unrelated healthy individuals by fluorescent PCR followed by fragment analysis. The genomic location of the markers is shown in Figure 1a and a representative graph of fragment analysis for each marker is shown in Figure 1b. Genotyping analysis of D16S475, D16S291, and D16S3252 revealed the presence of 19, 9, and 6 alleles in the studied Iranian population, respectively. Allele frequencies of the D16S475 and D16S291 markers have approximately uniform distribution, a key feature of informative markers [Figure 2]. The most common alleles for the D16S475 and D16S291 markers have a frequency of 0.14 and 0.27, respectively. However, for the D16S3252 marker, one allele alone had a frequency of 0.69 that significantly differs from the frequency of other alleles, implying a relatively lower HET for this marker.

To assess the informativeness of the markers, observed HET, expected HET, and PIC values were calculated based on allele frequencies [Table 2]. D16S475 and D16S291 with HET and PIC values >0.8 are highly informative markers. In addition, the D16S3252 marker with lower HET and PIC values is moderately informative in this population. The calculated HWE *P* value for D16S3252 was above 0.05. However, for D16S475 and D16S291, the population is not assumed to be in the HWE (*P* < 0.05).

Table 1: Characteristics of selected microsatellite markers including repeated sequence markers, sequence of primers, and polymerase chain reaction products size

Marker	Marker type	Primer sequence (5'→3')	Product size (bp)
D16S475	(GA) _n A(AAGA) _n	TGAACTGAGGTCCTACCACTG AGAAACTACTGGCAGGAACAGA	207-243
D16S291	(CA) _n	GATTACAGGCATGAACCACCA AGCAAGAAGCAGGCAGACA	233-249
D16S3252	(CA) _n	GTACACAGAAGCAGGCACAG GGCAAGTAGCAGGACTAGGC	183-199

DISCUSSION

Indirect genetic testing by linkage analysis is a reliable and practical approach for ADPKD diagnosis in clinical settings. This method is highly reliant on the presence of informative genetic markers. However, the informativeness of markers, expressed by HET and PIC values, is population dependent and should be assessed in the society that the test is planning to be established. In this study, the HET of three microsatellite markers for the *PKD1* gene, as the most responsible gene for ADPKD, was determined in Iranian population.

In the present study, microsatellite genotyping was performed for unrelated healthy individuals. We showed that D16S291 is a highly informative marker. This finding is consistent with another study on the Iranian population by Radpour *et al.*^[19] We demonstrated that the D16S3252 marker is moderately informative, whereas it was highly informative in that study. This discrepancy may be due to the diversity of the Iranian population and difference of the subpopulations of these two studies. Furthermore, these two markers are known as suitable markers for ADPKD genetic testing in most studied populations.^[8,13-15] In addition, for the first time, we found D16S475 to be highly informative in our population. This marker has also been reported as a suitable marker in some other studies.^[16]

In this study, fifty healthy individuals were randomly chosen. The selection of this sample size was based on a previous study by Hale *et al.* that showed only 25–30 individuals per population is enough to accurately estimate the number and frequency of common alleles and the calculation of related parameters.^[20] Determining the frequency and HET of rare alleles are of little value for

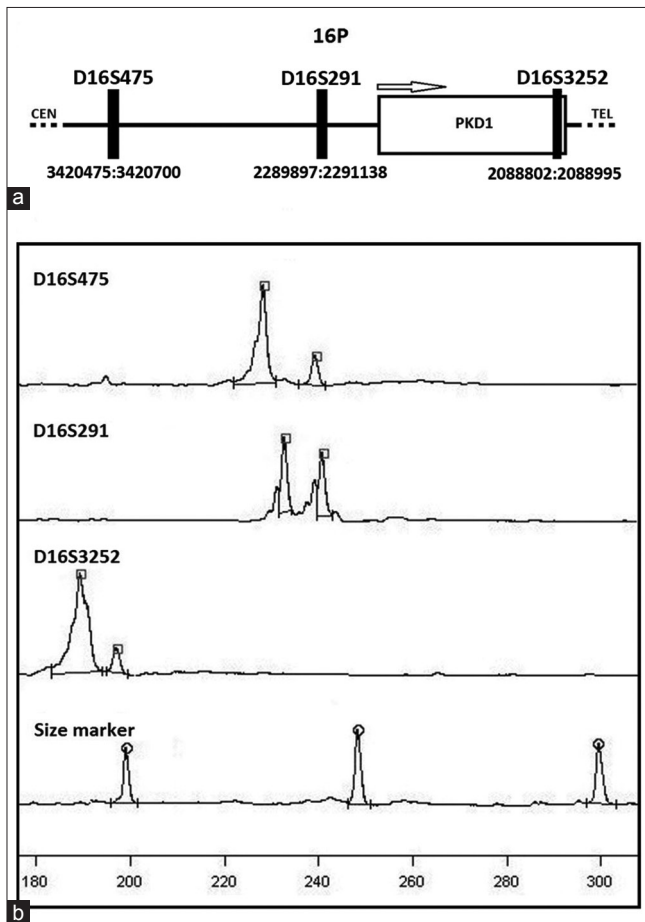


Figure 1: In this study, we assessed the informativeness of the polycystic kidney disease 1 gene markers D16S475, D16S291, and D16S3252 in an Iranian population. The genomic position of the polycystic kidney disease 1 gene microsatellite markers is shown (a). A representative graph of fragment analysis for each marker is demonstrated (b)

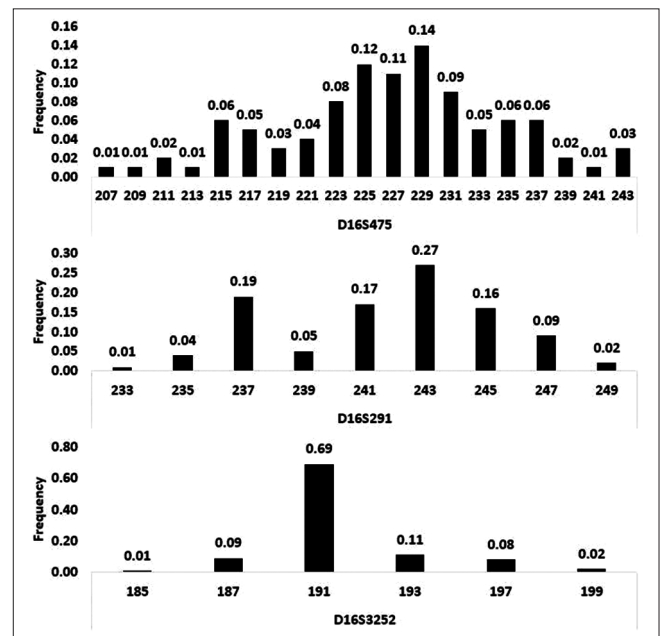


Figure 2: The number and frequencies of alleles for three microsatellite markers D16S475, D16S291, and D16S3252 for the polycystic kidney disease 1 gene were determined

Table 2: Number of genotypes, number of alleles, observed and expected heterozygosity, PIC value, and Fisher’s exact P value of three microsatellite markers for linkage analysis of ADPKD1 in the Iranian population

Marker	Number of genotypes	Number of alleles	Heterozygosity		PIC value	Exact (P)
			Observed	Expected		
D16S475	41	19	0.76	0.92	0.91	0.01
D16S291	20	9	0.54	0.82	0.80	0.00
D16S3252	10	6	0.44	0.50	0.47	0.44

PIC = Polymorphism information content, Exact (P)= Fisher’s exact P value: The probability of significant deviation from Hardy–Weinberg equilibrium

practical applications. A drawback of this study was the inability to show that the population is in the HWE for the D16S475 and D16S291 markers. This could be due to the relatively small sample size and the high number of alleles for these two markers. In spite of this limitation, the reported HET parameters for these two markers can be considered as acceptable estimations for clinical purposes.

CONCLUSION

In this study as a first step of indirect genetic testing for ADPKD, the HET of three microsatellite markers of the *PKD1* gene was determined. However, the suitability of more markers for the *PKD1* gene and the other responsible gene, *PKD2*, remains to be investigated in future studies.

Financial support and sponsorship

This study was supported by Isfahan University of Medical Sciences (Grant Number: 393406).

Conflicts of interest

There are no conflicts of interest.

REFERENCES

- Sessa A, Righetti M, Battini G. Autosomal recessive and dominant polycystic kidney diseases. *Minerva Urol Nefrol* 2004;56:329-38.
- Hughes J, Ward CJ, Peral B, Aspinwall R, Clark K, San Millán JL, *et al.* The polycystic kidney disease 1 (PKD1) gene encodes a novel protein with multiple cell recognition domains. *Nat Genet* 1995;10:151-60.
- Mochizuki T, Wu G, Hayashi T, Xenophontos SL, Veldhuisen B, Saris JJ, *et al.* PKD2, a gene for polycystic kidney disease that encodes an integral membrane protein. *Science* 1996;272:1339-42.
- Brunelli SM, Blanchette CM, Claxton AJ, Roy D, Rossetti S, Gutierrez B. End-stage renal disease in autosomal dominant polycystic kidney disease: A comparison of dialysis-related utilization and costs with other chronic kidney diseases. *Clinicoecon Outcomes Res* 2015;7:65-72.
- Pirson Y. Extrarenal manifestations of autosomal dominant polycystic kidney disease. *Adv Chronic Kidney Dis* 2010;17:173-80.
- Gibbs GF, Huston J 3rd, Qian Q, Kubly V, Harris PC, Brown RD Jr., *et al.* Follow-up of intracranial aneurysms in autosomal-dominant polycystic kidney disease. *Kidney Int* 2004;65:1621-7.
- Pei Y, Watnick T. Diagnosis and screening of autosomal dominant polycystic kidney disease. *Adv Chronic Kidney Dis* 2010;17:140-52.
- De Rycke M, Georgiou I, Sermon K, Lissens W, Henderix P, Joris H, *et al.* PGD for autosomal dominant polycystic kidney disease type 1. *Mol Hum Reprod* 2005;11:65-71.
- PKD Mutation Database. Available from: <http://www.pkdb.mayo.edu>. [Last cited on 2017 Jan 14].
- Bogdanova N, Markoff A, Gerke V, McCluskey M, Horst J, Dworniczak B. Homologues to the first gene for autosomal dominant polycystic kidney disease are pseudogenes. *Genomics* 2001;74:333-41.
- Barua M, Pei Y. Diagnosis of autosomal-dominant polycystic kidney disease: An integrated approach. *Semin Nephrol* 2010;30:356-65.
- Reyes-Valdés MH. Informativeness of microsatellite markers. *Methods Mol Biol* 2013;1006:259-70.
- Endreffy E, Maróti Z, Bereczki C, Túri S. Usefulness of combined genetic data in Hungarian families affected by autosomal dominant polycystic kidney disease. *Mol Cell Probes* 2009;23:39-43.
- Lee JG, Lee KB, Kim UK, Ahn C, Hwang DY, Hwang YH, *et al.* Genetic heterogeneity in Korean families with autosomal-dominant polycystic kidney disease (ADPKD): The first Asian report. *Clin Genet* 2001;60:138-44.
- Mizoguchi M, Tamura T, Yamaki A, Higashihara E, Shimizu Y. Genotypes of autosomal dominant polycystic kidney disease in Japanese. *J Hum Genet* 2002;47:51-4.
- Binczak-Kuleta A, Rozanski J, Domanski L, Myslak M, Ciechanowski K, Ciechanowicz A. DNA microsatellite analysis in families with autosomal dominant polycystic kidney disease (ADPKD): The first Polish study. *J Appl Genet* 2006;47:383-9.
- Aken BL, Ayling S, Barrell D, Clarke L, Curwen V, Fairley S, *et al.* The Ensembl gene annotation system. *Database (Oxford)* 2016;2016. pii: Baw093.
- Liu K, Muse SV. PowerMarker: An integrated analysis environment for genetic marker analysis. *Bioinformatics* 2005;21:2128-9.
- Radpour R, Rezaee M, Haghighi MM, Ohadi M, Najmabadi H, Hajibeigi A. Genetic heterogeneity of PKD1 and PKD2 genes in Iran and determination of the genotype/phenotype correlations in several families with autosomal dominant polycystic kidney disease. *Iran Biomed J* 2006;10:1-8.
- Hale ML, Burg TM, Steeves TE. Sampling for microsatellite-based population genetic studies: 25 to 30 individuals per population is enough to accurately estimate allele frequencies. *PLoS One* 2012;7:e45170.