



The Normal Static Two-Point Discrimination in the Palmar Aspect of Hand in Adults and Children in a Sample Indian Population

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Abstract

Background The normal ability to distinguish two points from one is known as the two-point discriminative (2PD) sense. This forms an extremely important assessment in patient with injuries to the nerves distributed to the upper extremity.

Objective The aim of this study was to estimate the normal reference values of static 2PD in healthy adults and children.

Materials and Methods A total of 624 normal adults comprising 380 men and 244 women were recruited randomly for the study at three different centers. Additionally, 172 healthy children, comprising 110 boys and 62 girls, were studied. Eight sensory areas in the palmar surface of the hand were delineated. The ability to distinguish the static 2PD was estimated in millimeters by using disk discriminator. The results were tabulated and statistically analyzed.

Results The mean static 2PD in the adult population ranged from 2.78 to 3.5 mm in the fingertips and 5.39 to 7.13 mm in the mid-palm. There was a statistically significant difference between men and women in zones 6, 7, and 8. In children, the observed 2PD values were 2.15 to 3.63 mm in the fingertips and 4.10 to 5.77 mm in the palm. Children have a significantly better 2PD sense when compared with adults.

Conclusion The normal value of static 2PD in the palmar surface of the hand among the Indian pediatric and adult populations was established in the study.

Keywords

- ▶ static two-point discrimination
- ▶ nerve injury
- ▶ sensory assessment
- ▶ disk discriminator normal value

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Introduction

Touch is a protective sensation. It protects our body from harm by transmitting the external stimulus to the brain via the spinal cord and peripheral nerves. The assessment of tactile sensation is a direct indicator of the state of central and peripheral nervous system. The static two-point discrimination (2PD) test measures the shortest distance when an individual is able to make out two points of the examining device that is used to stimulate the skin at the same time exerting similar pressure. 2PD is an accepted and validated measure of sensory assessment in the hand.¹

The static 2PD test is one of the most popular and most commonly used examination tools to evaluate peripheral nerve pathology and trauma and assess recovery after treatment. The 2PD test, first reported by Weber in 1835, describes the minimum distance between two points that is needed for the subject to feel two contacts.² This test is often used clinically to examine the sensation of the affected anatomical part. It is a cost-effective, user friendly, and highly sensitive tool, and is an essential tool in hand surgery. The normative values of both static and dynamic 2PD are reported in the Western literature, which is reported to be around 2.5 to 3.8 mm.^{3,4} In patients whose occupation requires precision, static 2PD is an important prognostic factor.^{3,5}

There is very limited literature on the normative values of static 2PD of the fingertips and the palm in Indian population. So this study aims at finding normal reference values of static 2PD in healthy children and healthy adults in the palmar surface of the hand with samples from different geographical areas of the country using disk discriminator. These normative values can be a useful guide for clinicians in sensory evaluation of patients.

Materials and Methods

This is a multicentric prospective observational study. The study was conducted as part of normative data project of the Indian Society for Surgery of the Hand, which aims to

measure the normative data for hand surgery in the Indian population. The study was done in Chennai, Mumbai, and Jabalpur. Institutional ethics committee approval was obtained for the study protocol in all the centers. The inclusion criteria of the study were healthy adult volunteers aged 18 to 65 years and healthy children aged between 5 and 17 years. The exclusion criteria were presence of any systemic disease like diabetes mellitus, hypertension, chronic kidney disease, asthma, seizure disorder, or patients on prolonged medications. Patients with any history of upper extremity fracture or musculoskeletal deformities and soft-tissue injuries or any neurological deficits in the upper extremity or any surgery in the hand were also excluded. Demographic details like place of residence, age, gender, and anthropometric data like handedness, height, and weight were collected prior to static 2PD assessment.

A pilot study of 20 individuals was done after obtaining informed consent to identify procedural difficulties and to assess the reliability of the study methodology. The first recording was done by the first author and the same 20 individuals were reexamined after 2 days to study intraobserver variation. Another observation was done by a senior therapist under the supervision of a hand surgeon. The data were collected and statistically analyzed to calculate interobserver variation.

Since this is a multicenter study, standardizing the methodology for data collection through online training sessions and regular meetings was done. Disk discriminators (►Fig. 1) were procured and shipped to the various study centers. The devices were calibrated in a standard laboratory prior to shipping. Proforma and master charts were provided to the individual centers for data collection.

2PD Measurement Technique

The palmar surface of the hand is divided into eight areas or zones starting from the fingertip of the thumb to little finger as five zones serially. The thenar eminence, mid-palm, and hypothenar eminence are numbered as zones 6, 7, 8, respectively (►Fig. 2).

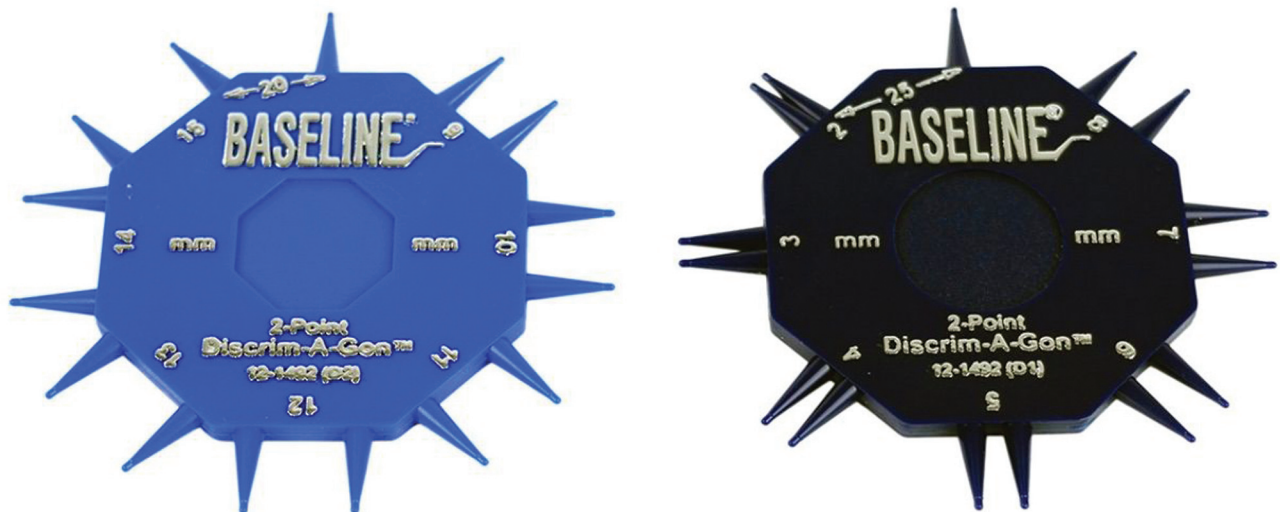


Fig. 1 Standard calibrated disk discriminator.

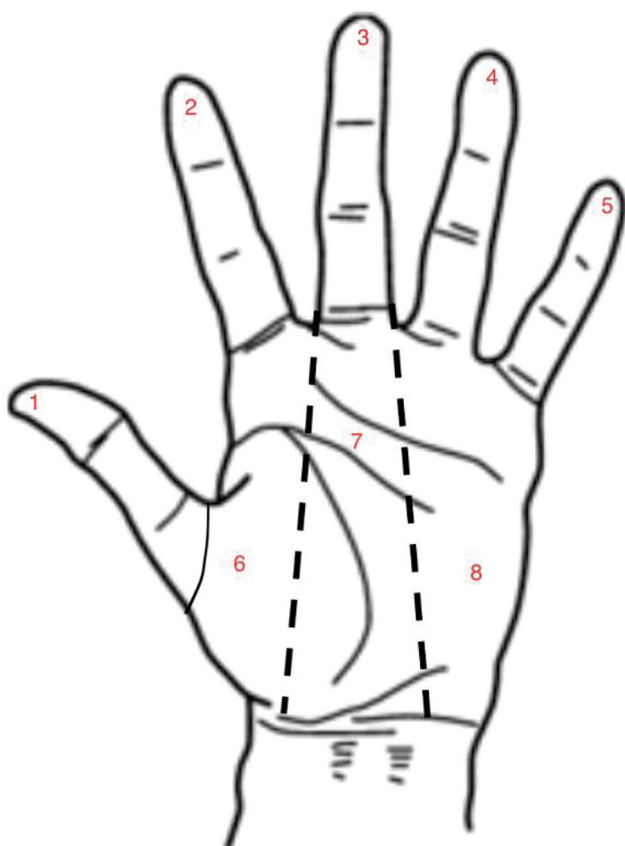


Fig. 2 Zones of the hand as per the study design.

The preparation and orientation of the individual for a 2PD test are done in a stepwise fashion. The volunteer's touch threshold is determined to ensure that the pressure applied during the test would not be painful and no blanching of palmar skin occurs. The volunteer is not blindfolded during orientation but is later blinded by a custom-made screen during the actual testing procedure. The individual is seated behind the screen and asked to place the hand through the opening in the screen. This ensures that the hand is not visible to the individual at the time of examination. The orientation involves familiarizing the individual with the testing device and the procedure.

During the familiarization, the examiner touches the prongs of the discriminator device on the area to be examined. The prongs are placed simultaneously to apply pressure on two adjacent points perpendicular to the palmar surface.⁶ The two prongs are oriented so that they lie in a transverse direction perpendicular to the longitudinal axis of the finger. First, one prong was used to touch the area to be examined and the individual was asked to describe what they feel. The individual was reinforced by being told "that was a single point." Next, both prongs of the device were used to touch the area examined. Six-millimeter prongs were used to examine the fingertips and 12-mm prongs were used to examine the volar surface of the hand. The individual was questioned again and was reinforced by being told "that was two." In the testing phase of the procedure, which involves gradually reducing the distance between the two prongs of the testing

device, the individual is first tested with the prongs 6 mm apart for the fingertips and 12 mm apart for the palmar skin of the hand, and the stimulus alternates between one and two prongs. If the individual can correctly identify the change, the distance between the prongs is reduced. When the individual begins to struggle with the task, at least two out of three correct responses are required before proceeding to another lower value.⁷ The 2PD value is determined when the individual can no longer distinguish two separate points. The children included in the study were oriented to the procedure along with the parent or guardian seated by their side on the first day. The next day after orienting them again, they were examined and recordings were made.

All statistical analyses were performed using SPSS, version 17 for Microsoft windows. The data were not normally distributed and therefore parametric and nonparametric tests were performed. Descriptive statistics were reported as numbers and percentages. The data were presented as mean and standard deviation (SD). Independent sample Student's *t*-test and Mann-Whitney *U* test were used to compare continuous variables between two groups. A chi-squared test was used for comparison between two attributes. A *p*-value less than 0.05 was considered statistically significant.

Results

A pilot study was conducted in Chennai. Twenty volunteers were studied. Interobserver reliability was assessed using the intraclass correlation coefficient and was found to be greater than 0.5 in all parameters. Intraobserver reliability was assessed using Cronbach's alpha and was found to be greater than 0.35 in all parameters, which was acceptable for the study methodology. Based on the pilot study results and using n-master software (v2.0) with power of 80% and α error 5% with a sample mean of 3.10 mm and standard deviation of 0.2, we arrived at the sample size of 594 for statistical significance.

A total of 796 volunteers were tested cumulatively in all centers. A total of 624 adult volunteers and 172 pediatric volunteers were included in the study. Demographic data like age and gender and anthropometric data like body mass index (BMI), hand dominance, height, and weight are listed in ►Table 1 and ►Table 2.

The normative values of the static 2PD test are reported in ►Table 3 and ►Table 4. The values ranged from 2 to 6 mm among the participants in the fingertips (zones 1–5) and the 2PD values in the palmar aspect of the hand ranged from 2 to 15 mm (zones 6–8) in the adult and pediatric populations. The study shows the static 2PD values in children were significantly less when compared with those of the adults (►Table 5; $p < 0.05$). A zone-wise comparison was done between the adult and pediatric populations. There were statistically significant differences between the adult and pediatric populations in all the zones except zone 4 of the left hand and zone 5 of the right hand.

The 2PD in males and females were similar in zones 1 to 5; however, females had a lower 2PD in zones 6, 7, and 8

Table 1 Descriptive data of the adult volunteers in the study

	Range	n	%	Mean	SD
Age (y)	18–65			29.52	7.86
Height (cm)	62–189			160.77	12.3
Weight (kg)	30–140			62.08	14.02
BMI (kg/cm ²)	13.09–49.15			23.95	4.79
Gender	Male	380	60.9		
	Female	244	39.1		
Hand dominance	Right	598	95.83		
	Left	22	3.52		
	Ambidextrous	4	0.64		
Age distribution	≤20 y	45	7.2		
	21–30 y	349	55.9		
	31–40 y	189	30.3		
	41–50 y	30	4.8		
	>50 y	11	1.8		
Geographical distribution	Chennai	248	39.7		
	Jabalpur	299	47.9		
	Bombay	77	12.3		

Abbreviations: SD, standard deviation.

Table 2 Descriptive data of the pediatric volunteers in the study

		n	%	Mean	SD
Age		172		10.25	3
BMI				15.6	3
Height				133.3	18
Weight				29	13
Age distribution	5–10 y	95	55.2		
	11–15 y	65	37.8		
	>15 y	12	7.0		
Gender	Male	110	63.9		
	Female	62	36		
Hand dominance	Right	165	97.1		
	Left	5	2.9		
Geographical distribution	Chennai	0			
	Jabalpur	0			
	Bombay	172	100		

Abbreviation: BMI, body mass index; SD, standard deviation.

(→ **Table 3**). These findings were not observed in the pediatric population (→ **Table 4**). There was no significant correlation with respect to height, weight, and BMI.

Discussion

Evaluating the static 2PD by the described methodology is reliable and quick.^{7,8} Studies have established that the disk

discriminator is a reliable tool for determining 2PD.⁸ This forms the basis of sensory assessment of healthy individuals and patients recovering from nerve injuries.³ In our study, we used a standard two-point disk discriminator that is commercially available. From the data collected, the discrimination of the two-point touch sensitivity in the fingertips is much more than that of the palm. This is due to increased free nerve endings in the fingertips.⁹

Table 3 Static 2PD in sample Indian adult population

	Gender	N	Right hand (mean ± SD), mm	p-value	Left hand (mean ± SD), mm	p-value
Zone 1	Male	380	2.93 ± 0.76	0.470	2.90 ± 0.71	0.792
	Female	244	2.98 ± 0.79		2.92 ± 0.74	
Zone 2	Male	380	2.97 ± 0.73	0.334	2.91 ± 0.73	0.033
	Female	244	2.90 ± 0.69		2.78 ± 0.67	
Zone 3	Male	380	3.12 ± 0.87	0.442	3.03 ± 0.85	0.474
	Female	244	3.04 ± 0.79		2.95 ± 0.72	
Zone 4	Male	380	3.32 ± 0.97	0.242	3.25 ± 0.99	0.086
	Female	244	3.22 ± 0.82		3.08 ± 0.78	
Zone 5	Male	380	3.44 ± 1.16	0.768	3.47 ± 1.11	0.274
	Female	244	3.51 ± 2.27		3.32 ± 0.94	
Zone 6	Male	380	6.00 ± 2.38	0.018	5.94 ± 2.24	0.004
	Female	244	5.52 ± 2.27		5.39 ± 2.03	
Zone 7	Male	380	6.80 ± 2.47	0.011	6.58 ± 2.29	0.002
	Female	244	6.25 ± 2.27		5.99 ± 2.13	
Zone 8	Male	380	7.13 ± 2.17	0.007	7.06 ± 2.02	0.000
	Female	244	6.61 ± 2.10		6.37 ± 2.06	

Abbreviations: SD, standard deviation; 2PD, two-point discrimination.
 Note: $p < 0.05$ is considered significant.

Table 4 Static 2PD in a sample of Indian pediatric population

	Gender	N	Right hand (mean ± SD), mm	p-value	Left hand (mean ± SD), mm	p-value
Zone 1	Male	110	2.30 ± 0.57	0.411	2.20 ± 0.45	0.338
	Female	62	2.26 ± 0.60		2.27 ± 0.52	
Zone 2	Male	110	2.33 ± 0.54	0.111	2.15 ± 0.35	0.248
	Female	62	2.21 ± 0.48		2.24 ± 0.50	
Zone 3	Male	110	2.57 ± 0.74	0.217	2.65 ± 0.66	0.516
	Female	62	2.45 ± 0.69		2.60 ± 0.71	
Zone 4	Male	110	2.87 ± 0.77	0.461	3.12 ± 0.71	0.413
	Female	62	2.97 ± 0.81		3.03 ± 0.77	
Zone 5	Male	110	3.47 ± 0.75	0.620	3.63 ± 0.70	0.942
	Female	62	3.42 ± 0.76		3.63 ± 0.68	
Zone 6	Male	110	4.16 ± 0.88	0.851	4.23 ± 0.96	0.934
	Female	62	4.10 ± 0.82		4.26 ± 0.89	
Zone 7	Male	110	4.96 ± 1.31	0.316	4.95 ± 1.11	0.547
	Female	62	4.71 ± 1.27		5.00 ± 1.26	
Zone 8	Male	110	5.45 ± 1.22	0.877	5.77 ± 1.21	0.439
	Female	62	5.45 ± 1.42		5.68 ± 1.30	

Abbreviations: SD, standard deviation; 2PD, two-point discrimination.
 Note: $p < 0.05$ is considered significant.

Agarwal et al described the drawbacks of the commercially available esthesiometer as pain due to sharp tips and not being user friendly due to repeated changes of the inter-prong distance.¹⁰ Crosby and Dellon reported that the esthesiometer shows a tendency for higher values of 2PD when compared with other devices.⁸ The disk discriminator nulli-

fies all the above-mentioned disadvantages. It ensures accuracy and a steady testing sequence with ease of rotation of the disk between one- and two-prong stimuli.

This is a multicentric study with multiple investigators, and to avoid errors we emphasized on standardization of methodology, instrumentation, and data collection. Multiple online

Table 5 Comparison of static 2PD between adult and pediatric Indian sample population

	Gender	N	Right hand (mean ± SD), mm	p-value	Left hand (mean ± SD), mm	p-value
Zone 1	Adult data	624	2.95 ± 0.77	0.000	2.91 ± 0.72	0.000
	Pediatrics data	172	2.28 ± 0.58		2.23 ± 0.47	
Zone 2	Adult data	624	2.94 ± 0.72	0.000	2.86 ± 0.71	0.000
	Pediatrics data	172	2.28 ± 0.52		2.18 ± 0.42	
Zone 3	Adult data	624	3.09 ± 0.84	0.000	3.00 ± 0.80	0.000
	Pediatrics data	172	2.53 ± 0.72		2.63 ± 0.68	
Zone 4	Adult data	624	3.28 ± 0.91	0.000	3.19 ± 0.92	0.426
	Pediatrics data	172	2.91 ± 0.78		3.09 ± 0.73	
Zone 5	Adult data	624	3.47 ± 1.68	0.087	3.41 ± 1.05	0.000
	Pediatrics data	172	3.45 ± 0.75		3.63 ± 0.69	
Zone 6	Adult data	624	5.81 ± 2.34	0.000	5.73 ± 2.18	0.000
	Pediatrics data	172	4.14 ± 0.86		4.24 ± 0.93	
Zone 7	Adult data	624	6.58 ± 2.41	0.000	6.35 ± 2.25	0.000
	Pediatrics data	172	4.87 ± 1.30		4.97 ± 1.16	
Zone 8	Adult data	624	6.93 ± 2.16	0.000	6.79 ± 2.06	0.000
	Pediatrics data	172	5.45 ± 1.29		5.74 ± 1.24	

Abbreviations: SD, standard deviation; 2PD, two-point discrimination. Note: p-value <0.05 is considered significant.

training sessions were conducted and standard proformas were distributed to different centers to standardize the methodology and data collection. Disk discriminators were procured and calibrated at a National Accreditation Board for Testing and Calibration Laboratories (NABL)-accredited laboratory. The parameters used for calibration included the dimensions of various aspects of the instrument. These devices were shipped to the respective centers for the study to ensure uniformity of instrumentation. This ensured consistency among observers and minimized discrepancies. This standardization strengthened the reliability and accuracy of the collected data.

Our study was performed to obtain normal reference values of static 2PD in the palmar aspect of the hand in the Indian population. Considering the difficulty in standardizing the measurement of dynamic 2PD, it was excluded and only static 2PD was utilized in our study.

A study conducted by Jagad and Dhanesha Karishma et al reported the 2PD of the index and little fingertips. Their study showed higher 2PD values in the little fingertip.¹¹ Our study showed a similar pattern with zones falling in the ulnar nerve distribution having higher 2PD values when compared with zones falling in the median nerve distribution. This difference was statistically significant in the pediatric population alone.

In our study, there is an increase in 2PD values with age as seen in our pediatric and adult data. van Nes et al have shown increasing 2PD values with age, similar to our study. The increase in 2PD values may be due to various reasons like a change in the number of Meissner’s corpuscles, morphological change in pacinian corpuscles, degeneration, and demyelination.¹²

Most of the existing studies measure the 2PD in the median and ulnar distribution of the hand and the forearm;

however, our study investigates the 2PD of the hand in eight different zones as described earlier.^{3,4,11,13,14} We have divided the hand into eight different zones based on the anatomical region rather than nerve supply. This was to emphasize that the function of each anatomic zones affects the 2PD. As an example, the fingertips have a lower 2PD when compared with the palm due to the inherently higher sensibility requirements of the fingertips. Hence, we believe that our technique assesses the 2PD data of the hand in much more detail. Our study measures the 2PD of the median nerve distribution in zones 1, 2, 3, and 6, and ulnar nerve distribution in zones 5 and 8. Zones 4 and 7 have innervation by both the median and ulnar nerves.

In our study, children show better 2PD values in the zones representing the median nerve distribution and combined innervation, which is statistically significant. This is previously reported by Gellis and Pool who stated that the higher number of Meissner’s corpuscles, which are located at the fingertips, increases the sensitivity of the fingertips. The number of corpuscles reduces as the person ages, which might explain why children have a better 2PD.⁵ This also explains why the fingertips have a better 2 PD when compared with the rest of the hand.

Our study reports 2PD sensitivity decrease from the distal to the proximal aspect of the hand. Thube et al reports a similar pattern of results in study conducted in middle-aged adults in the Indian population.¹⁵

In a study conducted in the Korean population, the 2PD value is 4.1 and 5.3 over the palmar surface of the distal interphalangeal (DIP) joint for women and men, respectively,¹⁶ whereas in our study in the corresponding anatomical area, the 2PD is 2.90 and 2.98 for men and women,

respectively. They have also reported that women have a lower 2PD than men, which is also noted in our study especially in zones 6, 7, and 8, which correspond to the palm of the hand. The reasons proposed is that the sensory homunculus area correlates to the relative size of the cortex receptive field and that women have greater cortex receptive fields for the hand compared with men.¹⁶

Limitations of the Study

Since it is a multicenter study, there is a chance of selection bias and interobserver variability. It is for this reason that we have excluded the measurement of the dynamic 2PD due to difficulty in standardization. In addition, measurement of the 2PD in children is relatively inaccurate due to the shorter attention span of the pediatric population and their natural inclination to make guesses.

Conclusion

This study shows the normative data for the 2PD distribution in the eight zones in the palmar aspect of the hand in adults and children in a sample of Indian population. The values of the 2PD in the fingertips are lower in comparison to the proximal parts of the hand.

Authors' Contribution

S.K.P. was the Principal Investigator for the project as a whole and the Principal Investigator for the project in the south zone, and contributed to data collection and writing the manuscript. M.R.T. was the Principal Investigator for the projects in Mumbai and West Zone, and Patron of the ISSH Normative data project, and contributed to data collection and editing the manuscript. P.A. was the Principal Investigator for the project in Jabalpur and contributed to data collection. S.R. was the Principal Investigator for the project in Saveetha Medical College, and contributed to data collection. M.I. contributed to manuscript writing and data analysis. V.B.G. contributed to data collection. A.N.S. contributed to manuscript writing. L.M., M.S., R.B., B.G., H.R.S., and O.K. contributed to data collection. A.D. contributed to data collection and entry. R.K. provided logistical support and contributed to editing the manuscript. S.R. contributed to data collection and manuscript writing. A.B. was the coordinator of the ISSH Normative data project, and contributed to editing the manuscript. K.S. contributed to designing the methodology and editing the manuscript.

Institutional Review Board

Institutional review board clearance was obtained for the study individually at the four participating centers where the study was performed and the study protocols conformed to the Declaration of Helsinki.

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None.

Conflict of Interest

None declared.

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