Smartphones and Programmable Shunts: Are These Indispensable Phones Safe and Smart?

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■ OBJECTIVE: **This study aimed to determine whether smartphones affect programmable shunts.**

■ METHODS: **iPhone 5S (Apple Inc., Cupertino, CA, USA) and Samsung Galaxy S5 (Samsung Electronics, Gumi, South Korea) smartphones were chosen for this study. For both phones, magnetic field mapping was performed with 3-dimensional magnetic scanning systems constructed with high-precision motorized stages, and a Hall effect sensor was used to measure the flux density on the smartphone surface. The distance (*h*) between the distal outlet of the reservoir and the rugby ball of the Strata valve (Medtronic Inc., Minneapolis, MN, USA) was measured using highly sensitive microanalysis optical method. During optical microanalysis, while keeping a 3-cm distance between the valve and the magnetic generator, the *h* value (μm) was recorded for different magnetic flux densities (MFDs). Then, direct x-ray radiography was performed for radiologic assessment after each process under different magnetic fields. For analysis of the Codman Certas valve (Codman Neuro, Raynham, MA, USA), the magnet orientation and the angle between the magnet with the tantalum ball were measured with the same optical analysis.**

■ RESULTS: **Maximum MFDs found 62 G for iPhone 5S and 61 G for Samsung Galaxy S5. When the magnetic generator formed a current at 0, 30, 60, and 90 G, the *h* values of the Strata valve adjusted to 100 mm H_2O opening pressure were 320, 280, 190, and 175 μm, respectively. When the magnetic generator was removed from the environment, the *h* value returned to 320 μm. In direct graphs taken after each optical analysis at different Gauss values, substitution was not observed at the indicator. The angle in the Codman Certas valve was 123.9°, 112.5°, and 103.6° at the magnetic flux densities of 0, 60, and 90 G, respectively. When the magnetic field was removed (0 G), the angle was still 103.6°, suggesting an irreversible effect in the shunt construct.**

■ CONCLUSIONS: **Smartphones exert reversible effects on Strata programmable valves without producing remarkable radiologic findings and irreversible effects on Codman Certas valves.**

INTRODUCTION

In parallel with technology's development, especially in the last 15 years, communication technologies have accelerated worldwide. The first smartphone was released into the market in 1994,[1] and the smartphone market has gained serious momentum in subsequent years. According to 2012 data, more than 1 billion smartphones are used worldwide.[2] Smartphones constitute 65% of mobile phones used in the whole market.[3] Apart from the life-facilitating features of these devices that are accepted as an inseparable part of our daily lives, the first results of their psychologic and organic side effects on our health have been published recently.[4,5]

One of the most frequently encountered diseases in neurosurgery practice is hydrocephalus, and its treatment is mostly surgical. The primary aim in hydrocephalus surgery is to reduce intracranial pressure, and ventricular shunt systems are used for this purpose. Although hundreds of different shunt types are available, the primarily preferred shunts are conventional constant pressure shunts and programmable shunts. Pressure adjustments

Key words
- Hydrocephalus
- Magnetic field
- Programmable valve
- Shunt
- Smartphone

Abbreviations and Acronyms
3D: 3-dimensional

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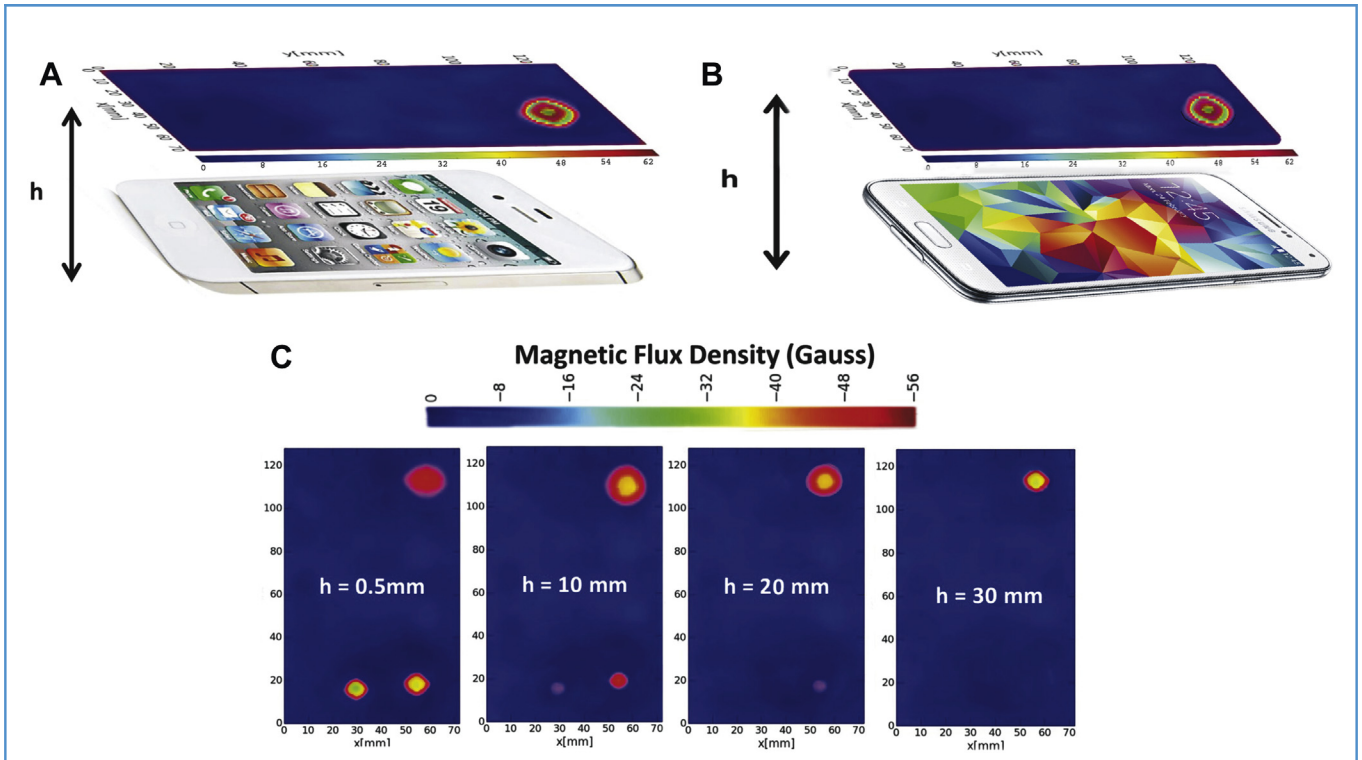

Figure 1. Magnetic flux measurement of (**A**) iPhone 5S and (**B**) Galaxy S5, and (**C**) mean magnetic flux density of both smartphones at different distances.

in programmable shunt valves may be made by evaluating a patient's clinical and radiologic findings without the need of any surgical or interventional processes. There may be changes, mostly involuntary, in pressure adjustments of valves in environments with very high magnetic fields.[6-10] In such instances, patients develop increased intracranial pressure or shunt overdrainage.[7]

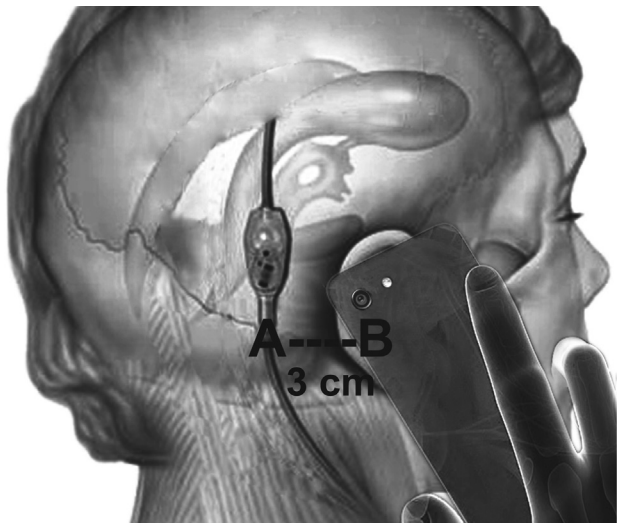

Figure 2. Illustration shows the 3-cm distance (the distance between points A and B) between the programmable valve and maximum magnetic flux density of the smartphone.

In this study, we used highly sensitive methods in a laboratory environment to assess whether smartphones have an effect on programmable shunts and whether they are associated with temporary or permanent pressure changes in programmable valves.

MATERIALS AND METHODS

The iPhone 5S (Apple Inc., Cupertino, CA, USA) and Samsung Galaxy S5 (Samsung Electronics, Gumi, South Korea) smartphone models, which dominate approximately 40% of the smartphone market, were chosen for this study.[11] For both phones, a magnetic field mapping technique was applied to measure the magnetic flux density at different axial and lateral distances during 3 different usage periods (standby, talking, and talking during charging) (Figures 1A and B). The 3-dimensional (3D) magnetic scanning system constructed with high-precision motorized stages (PSARON, Ankara, Turkey) and a Hall effect sensor (Honeywell, Morris Plains, New Jersey, USA) was used to measure the flux density on the smartphone surface with axial and lateral resolution of 5 and 1 mm, respectively. Each smartphone was tested 3 times. The density values measured at 4 different axial distances are delineated in Figure 1C. Afterward, magnetic generators that exactly imitate the magnetic effect of smartphones were used in the experiments using a Strata II programmable valve