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Original Research

The Impact of MRI Findings on Treatment Planning for Schizophrenia

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Abstract

Introduction: Schizophrenia is a complex mental illness that touches the lives of about 1% of the world's population. Modern neuroimaging techniques, especially Magnetic Resonance Imaging (MRI), can provide deep insights into the brain bases of schizophrenia. This study was designed to investigate how the findings of MRI scans might affect treatment decisions that are made in a tertiary care hospital for people with schizophrenia.

Methods:A prospective observational study was conducted for one year amongst 150 patients with schizophrenia. The participants underwent comprehensive clinical assessment, along with structural and functional MRI. Decisions on treatment planning were evaluated before and after reviewing MRI. Follow-up assessments were done after 3 months in terms of the outcome of treatment.

Results: Structural and functional brain imaging showed important cortical thinning in 61.3% of the cases and abnormal connectivity within the default mode network in 63.3%. MRI review led to significant changes in treatment planning, including increased rates of recommendation for cognitive remediation (30.0% vs 58.0%, $p<0.001$) and for changes in antipsychotic medications (21.3% vs 38.7%, respectively, $p<0.001$). Cortical thickness in the dorsolateral prefrontal cortex was the most important predictor of response to treatment in univariate analyses (OR = 1.8, 95% CI: 1.3-2.5, $p = 0.002$).

Conclusion: Findings on MRI significantly influence treatment planning in schizophrenia and provide informative predictors of response to treatment. In the future, integration of neuroimaging into clinical practice promises personalization and improvement of strategies for the treatment of schizophrenia. This translation is challenging into routine clinical care and also requires further investigation into developing clinician-friendly tools for interpretation of neuroimaging data.

Keywords: Schizophrenia, Magnetic Resonance Imaging, Treatment Planning, Personalized Medicine, Neuroimaging Biomarkers

Introduction

Schizophrenia: this is one of the most chaotic and disabling disorders, affecting approximately 1% of the world's population (World Health Organization, 2022). It affects thinking, perception, emotions, language, sense of self, and behavior, creating problems for both the patients and professionals, and its heterogeneous nature makes it a challenge, especially because it has a chronic course and may have severe disability; hence, diagnosis, treatment, and management require a multi-faceted approach (Tandon et al., 2013).

Over the last few decades, neuroimaging techniques have developed strongly, especially MRI, and changed our perceptions about the neurobiological basis of schizophrenia. MRI has proved to give images of excellent resolution without the invasion of the brain, which makes it of immense utility in imaging the neural correlates of schizophrenia symptoms and treatment responses (Vita et al., 2015). With the understanding that brain alterations due to schizophrenia increase its potential utility in the guidance of treatment planning.

By integrating MRI findings into clinical practice, an important distinction in psychiatry is made. MRI is not only useful as a way to visualize a lesion or other abnormality. By showing differ ences in brain structure and function that are unique to each person, MRI can potentially help clinicians tailor their treatment strategies according to the personality characteris tics-perhaps even including aspects of an individual patient's history-that they observe most vividly in him. This

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means fewer drugs with serious side effects. It also means a raised level of care for people with schizophrenia (Dazzan et al. 2015).

Several key areas of MRI research have shown particular relevance to treatment planning in schizophrenia:

Structural Changes in the Brain: Different studies have shown that the brain structure of sufferers of schizophrenia is not normal. Gray matter volume decreases, the cortex becomes thinner and white matter integrity is compromised in various ways (van Erp et al., 2018). Head imaging research on schizophrenia has found that some of these structural changes are related to such clinical features of the disorder as cognitive deficits, negative symptoms or treatment response. For example, one study done by Padmanabhan et al. (2015) found that outcomes of antipsychotic therapy were likely to be worse in patients whose grey matter volume was reduced in their dorsolateral prefrontal cortex. Such discoveries may point to a future when structural MRI could be used to predict how well various drugs will work and guide medication selection.

Functional Changes in Brain: Functional imaging shows the schizophrenic brain as a whole has gone wrong, with patterns of activity and connectivity that differ from those in people without the illness (Dong et al. 2018). These functional alterations will impact on how treatment is planned. For example, Sarpal et al. (2015) found that the level and location of functional connectivity in the striatum could predict what kind of antipsychotic therapy the patient was likely to respond to. This suggests a possible role for fMRI in drug selection and monitoring.

Neurochemical Changes in the Brain: Magnetic Resonance Spectroscopy (MRS) is an advanced MRI-based technique that measures brain metabolites non-invasively. In people with schizophrenia, MRS studies have detected differences (in different parts of the brain) for various types of neurochemicals, such as glutamate, GABA and N-acetyl aspartate (Poels et al., 2014). Such neurochemical profiles may help in choosing treatment, especially at a time when new therapeutic approaches targeting specific transmitter systems are being spoken of Brain.

Development and the Course of the Disease: Longitudinal MRI studies have given insight into the unfolding process of changes in the brain in schizophrenia. They have revealed how this disorder develops from its earliest prodromal phase through to chronic illness, and possibly beyond (Cannon et al., 2015). Learning these developmental trends can help with early intervention strategies and in predicting course of disease so that long-term treatment planning is possible.

Treatment Monitoring: MRI can be utilized to check for changes in the brain associated with treatment. This provides an objective measure of treatment response and perhaps some idea about side effects that may follow treatment. As for antipsychotic medications, say studies have revealed changes in brain structure and function (Ho et al.,2011). MRI can detect these abnormalities-which means you could possibly keep watch on patients' drug-taking habits and chances for early-stage complications.

Such an integration of MRI in treatment planning promises much but poses several challenges. Because of its heterogeneous nature, such a disorder as schizophrenia leads to variable findings on MRI, thereby complicating efforts at standardization (Kapur et al., 2012). More importantly, the nonspecific nature of some of the alterations observed in the brain, like the features observed in psychiatric conditions other than schizophrenia, limits the diagnostic and prognostic value of MRI (Goodkind et al., 2015). However, there is a substantial clinical need to translate the findings into clinically useful tools, and more research is needed to determine if this will become a true predictor of value and clinical utility in routine patient care settings (Dazzan, 2014). The cost-intensive nature of MRI is likely to restrict its wide use in routine clinical practice, particularly within resource-limited setups (Jääskeläinen et al., 2018). This complicates the proper interpretation of such MRI data and demands specialized expertise, which might not always be available in clinical settings; hence, the need for developing user-friendly tools for clinicians (Winterburn et al., 2019). Despite the challenges mentioned, some key research areas currently under study are likely to dictate the future influence of MRI in treatment planning in schizophrenia. Included in these areas are machine learning and artificial intelligence's application to the patterns and biomarkers in the MRI data (Dwyer et al., 2018), multimodal imaging to bring about a more holistic view of the brain structure and function (Amador et al., 2022), longitudinally trace progressive changes in the brain (Cropley et al., 2017), new treatment avenues (Kubera et al., 2019), and consolidating MRI results with genetic and molecular data (Doan et al., 2017). These innovations can be used to enhance the accuracy and clinical application of MRI in treatment outcome prediction, intervention guidance toward patient-specific care, and further management of schizophrenia.

The impact of MRI findings on the treatment planning of schizophrenia is a promising frontier in psychiatric research and clinical practice. MRI can revolutionize our approach to diagnosing, treating, and managing

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schizophrenia through providing detailed insight into brain structure, chemistry, and function. However, such potential will materialize only if ongoing research takes into account the present-day limitations and issues; rather, efforts translate into practical, clinically useful tools. Since we learn more about neurobiology in schizophrenia and fine-tune our techniques of neuroimaging, the usage of MRI findings in treatment planning has much promise for the improvement of outcomes and quality of life in schizophrenia.

Methodology

This research was designed to establish the impact of results obtained from MRI on the treatment dispensed to schizophrenia patients. The study was carried out for the period of 12 months fromJune 2023 to July 2024 at the Department of Psychiatry and Radiology, Rama Medical College, Kanpur.

Study Design*:* A prospective observational study design was employed to examine the relationship between MRI findings and treatment decisions in patients with schizophrenia.

Inclusion and Exclusion Criteria

Inclusion criteria were: (1) patients aged 18-65 years; (2) diagnosis of schizophrenia according to DSM-5 criteria; (3) ability to provide informed consent; and (4) willingness to undergo MRI scanning. Exclusion criteria were: (1) presence of any contraindications to MRI (e.g., metallic implants, claustrophobia); (2) comorbid neurological disorders; (3) history of significant head trauma; (4) current substance use disorder (except nicotine); and (5) pregnancy or breastfeeding.

Data Collection Tools and Techniques- Data collection involved several components:

1. Clinical Assessment: Participants underwent a comprehensive clinical assessment, including:
- Structured Clinical Interview for DSM-5 (SCID-5) to confirm the diagnosis of schizophrenia (First et al., 2015).
- Positive and Negative Syndrome Scale (PANSS) to assess symptom severity (Kay et al., 1987).
- Brief Assessment of Cognition in Schizophrenia (BACS) to evaluate cognitive function (Keefe et al., 2004).
- Personal and Social Performance Scale (PSP) to assess social functioning (Morosini et al., 2000).

2. MRI Scanning: All participants underwent structural and functional MRI scanning using a 3T MRI scanner. The MRI protocol included:
- T1-weighted structural imaging
- Resting-state functional MRI
- Diffusion Tensor Imaging (DTI)
- Magnetic Resonance Spectroscopy (MRS) of the dorsolateral prefrontal cortex and anterior cingulate cortex

3. Treatment Planning Questionnaire a standardized questionnaire was applied to determine whether the MRI findings exerted an influence on the treatment: This questionnaire was completed by treating psychiatrists both before and after seeing MRI results. It includes the following items:
- Medication choices (type and dosage)
- Psychosocial intervention recommendations
- Prognosis assessment
- Treatment monitoring plans

4. Follow-up Assessment: Based on the end of the three-month follow-up study, all those who were in treatment back in March are now re-evaluated. Following assessments include Severity of symptoms (PANSS), Cognitive capacity (BACS), and Social adjustment (PSP).

Statistical Analysis

Data were managed and analyzed with SPSS v26.0. Descriptive statistics, paired t-tests, and multiple regression analyses were employed.

Results

The study's findings offer significant insights into the role of MRI in treatment planning for schizophrenia. Table 1 presents a sample of 150 participants with established schizophrenia, characterized by moderate symptom severity (mean PANSS score of 72.4) and cognitive impairment (BACS composite score of -1.2). This sample provides a representative basis for investigating the impact of neuroimaging on clinical decision-making.

Tables 2 and 3 reveal a high prevalence of structural and functional brain abnormalities. Structurally, "cortical thinning (61.3%) and ventricular enlargement (52.0%)" are most common, while functionally, "altered default mode network connectivity (63.3%) and reduced prefrontal activation during working memory tasks (59.3%)" predominate. These findings align with existing literature on brain alterations in schizophrenia and highlight the potential utility of MRI in characterizing neural changes.

Table 4 demonstrates significant metabolic alterations in the dorsolateral prefrontal cortex, including "a 15.5% reduction in N-acetyl aspartate (NAA) and an 8.3% increase in glutamate levels." These changes support neurodegenerative and glutamate hypotheses of schizophrenia, offering potential targets for novel interventions.The impact of MRI findings on treatment planning is evident in Table 5, which shows significant increases in various treatment decisions post-MRI

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review. Notably, "recommendation for cognitive remediation... increased from 30.0% to 58.0% (p<0.001)," suggesting that MRI findings prompted more targeted cognitive interventions.

Finally, Table 6 demonstrates the predictive value of MRI measures for treatment response. "Cortical thickness in the dorsolateral prefrontal cortex" emerged as "the strongest predictor (OR = 1.8, 95% CI: 1.3-2.5, p = 0.002)," indicating that preserved prefrontal structure may be associated with better treatment outcomes.

Collectively, these results underscore the potential of multimodal neuroimaging to inform personalized treatment strategies and predict outcomes in schizophrenia. However, challenges remain in translating these findings into routine clinical practice, necessitating further research and development of clinician-friendly tools for neuroimaging data interpretation.

Table 1: Demographic and Clinical Characteristics of the Study Sample

Characteristic	Value (N = 150)
Age, mean ± SD (years)	32.5 ± 9.8
Gender, n (%)	
Male	87 (58.0%)
Female	63 (42.0%)
Duration of illness, mean ± SD (years)	7.3 ± 5.2
PANSS total score, mean ± SD	72.4 ± 15.6
BACS composite score, mean ± SD	-1.2 ± 0.9
PSP total score, mean ± SD	56.3 ± 12.7

Table 2: Prevalence of Structural MRI Abnormalities

MRI Finding	Prevalence, n (%)
Ventricular enlargement	78 (52.0%)
Cortical thinning	92 (61.3%)
Reduced hippocampal volume	63 (42.0%)
White matter abnormalities	55 (36.7%)
Reduced total brain volume	70 (46.7%)

Table 3: Functional MRI Findings

MRI Finding	Prevalence, n (%)
Reduced prefrontal activation during working memory tasks	89 (59.3%)
Altered default mode network connectivity	95 (63.3%)
Abnormal striatal activation	72 (48.0%)
Reduced lateralization of language function	58 (38.7%)
Aberrant salience network activity	83 (55.3%)

Table 4: MRS Findings in the Dorsolateral Prefrontal Cortex (DLPFC)

Metabolite	Mean ± SD (Institutional Units)	% Difference from Healthy Controls
NAA	8.2 ± 1.5	-15.50%
Glutamate	11.8 ± 2.3	8.30%
GABA	1.9 ± 0.4	-12.40%
Choline	2.4 ± 0.5	5.20%
Myo-inositol	5.7 ± 1.1	3.60%

Table 5: Impact of MRI Findings on Treatment Planning Decisions

Treatment Decision	Before MRI Review	After MRI Review	p-value
Change in antipsychotic medication	32 (21.3%)	58 (38.7%)	<0.001
Addition of mood stabilizer	18 (12.0%)	29 (19.3%)	0.03
Recommendation for cognitive remediation	45 (30.0%)	87 (58.0%)	<0.001
Adjustment of psychosocial interventions	56 (37.3%)	92 (61.3%)	<0.001
Consideration of TMS/tDCS	12 (8.0%)	35 (23.3%)	<0.001

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Table 6: Predictors of Treatment Response at 3-Month Follow-up

Predictor	Odds Ratio (95% CI)	p-value
Cortical thickness in DLPFC	1.8 (1.3-2.5)	0.002
Default mode network connectivity	1.5 (1.1-2.0)	0.01
NAA levels in DLPFC	1.6 (1.2-2.2)	0.005
Striatal activation during reward tasks	1.4 (1.0-1.9)	0.04
White matter integrity (FA in arcuate fasciculus)	1.7 (1.2-2.3)	0.003

Discussion

The findings of this study provide important insights into the potential impact of MRI findings on treatment planning for schizophrenia. Table 1 presents the demographic and clinical characteristics of our study sample. The mean age of participants was 32.5 years, with a slight predominance of males (58%). The average duration of illness was 7.3 years, indicating a sample of patients with established schizophrenia rather than first-episode cases. The mean PANSS total score of 72.4 suggests a moderate level of symptom severity (Table 1), which is consistent with previous studies of chronic schizophrenia patients (Leucht et al., 2005). The negative BACS composite score (-1.2) indicates cognitive performance below the normative mean, aligning with the well-documented cognitive deficits in schizophrenia (Keefe et al., 2011). The mean PSP score of 56.3 reflects moderate difficulties in social functioning, a common feature in schizophrenia (Juckel et al., 2008).

The high prevalence of structural and functional brain abnormalities in our sample (Tables 2 and 3) is consistent with the extensive literature on brain alterations in schizophrenia. However, the novelty of our study lies in examining how these neuroimaging findings influence clinical decision-making and predict treatment outcomes.Table 2 reveals a high prevalence of structural brain abnormalities, with cortical thinning (61.3%) and ventricular enlargement (52.0%) being the most common, consistent with meta-analyses of structural MRI studies in schizophrenia (van Erp et al., 2018). These findings underscore the potential utility of structural MRI in characterizing brain changes, though it's noted that such changes are not specific to schizophrenia (Goodkind et al., 2015). Table 3 presents functional MRI findings, showing altered default mode network connectivity (63.3%) and reduced prefrontal activation during working memory tasks (59.3%) as the most common abnormalities, aligning with literature on functional brain alterations in schizophrenia (Whitfield-Gabrieli& Ford, 2012; Minzenberg et al., 2009). Table 4 demonstrates significant metabolic alterations in the dorsolateral prefrontal cortex, including a 15.5% reduction in NAA and an 8.3% increase in glutamate, supporting neurodegenerative and glutamate hypotheses of schizophrenia (Brugger et al., 2011; Poels et al., 2014). The impact of MRI findings on treatment planning is evident in Table 5, showing significant increases in treatment decisions post-MRI review, such as cognitive remediation recommendations increasing from 30.0% to 58.0% ($p<0.001$). Table 6 demonstrates the predictive value of MRI measures for treatment response, with cortical thickness in the dorsolateral prefrontal cortex emerging as the strongest predictor (OR = 1.8, 95% CI: 1.3-2.5, $p = 0.002$), aligning with previous research linking prefrontal structure to treatment outcomes (Cannon et al., 2015). These results collectively underscore the potential of multimodal neuroimaging to inform personalized treatment strategies and predict outcomes in schizophrenia, although challenges in clinical translation remain (Winterburn et al., 2019).

The significant changes in treatment planning decisions after MRI review (Table 5) suggest that neuroimaging information can substantially influence clinical management strategies. The increased consideration of cognitive remediation after MRI review is particularly noteworthy. This aligns with the growing recognition of cognitive deficits as a core feature of schizophrenia and a major determinant of functional outcomes (Green et al., 2019). The structural and functional abnormalities observed in our sample, particularly in prefrontal regions associated with cognitive control, likely prompted clinicians to prioritize cognitive interventions.The increased propensity to change antipsychotic medications after MRI review suggests that neuroimaging findings may guide more personalized pharmacological strategies. This could reflect an attempt to tailor medication choices based on individual brain characteristics. For instance, patients with higher dopaminergic pathophysiology (such as presence of abnormal striatal activation) may receive drugs for which they have higher affinity to the D2 receptors, although evidence remains still rather limited in the role of neuroimaging to guide specific drug selection in schizophrenia (Dazzan et al. 2015).

Our treatment response predictors we found in this study (Table 6) may be potential biomarkers for the conceptualization of tailored personalized treatment strategies in schizophrenia. The preponderant superior predictive ability of cortical thickness in DLPFC was concordant with previous studies implicating relations between structure within the prefrontal area and outcome after treatment, as described by Cannon et al. (2015). This therefore means that those patients whose cortical thickness in the prefrontal region is well

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preserved would be suited for the traditional treatments while the patients whose cortical thickness is very low necessitate more intense or alternative treatments. The development of white matter integrity as the key predictor of the response to treatment supports the credibility of disconnection hypothesis regarding schizophrenia (Friston et al., 2016). It could potentially give an estimation of structural connectivity, especially in the most clinically important white matter tracts such as the arcuate fasciculus. Such a measure may also aid in the planning of treatment. Patients with better-preserved integrity of the white matter might have a better prognosis and could thus become candidates for less intensive treatments. The predictive value of functional measures-including default mode network connectivity and striatal activation may be sufficient to justify this objective of launching the potential for guiding treatment decisions with fMRI. Changes in the connectivity in the default mode network have been linked to many symptoms of schizophrenia, including cognitive impairment and negative symptoms (Whitfield-Gabrieli and Ford, 2012). In this regard, the findings of the study indicate that the degree of default mode network dysconnectivity informs the intensity of needed interventions or the focus of psychosocial treatments.

From the perspective of treatment responsiveness, MRS levels may predict NAA levels play a role, which warrants utility in clinical decision-making. NAA is generally viewed as an indicator of neuronal integrity; therefore, declines have been correlated with poor cognitive functioning in schizophrenia. Results reported here may suggest value in MRS with regard to degree of neuronal compromise-implied calls for tailoring intensity of neuroprotective and cognitive enhancement efforts. While promising, several limitations and challenges should be noted. Our observational study's design limits causal inferences about how MRI-informed treatment decisions might affect patient outcomes. Such studies will require randomized controlled trials comparing MRI-informed versus standard approaches to treatment to establish clinical utility of neuroimaging in schizophrenia care.

In addition, the difficulty of understanding multimodal neuroimaging data in individual patients remains quite tremendous. While our study found that certain things could predict better treatment responses from people with particular disorders, what this means for Doctors and their patients is still something we need to study more deeply and work on making clear points about. Making this known to the doctors with their patients is difficult; it needs further investigation and tools that are simple enough for the clinician to use to read data from this study. (Winterburn et al. 2019) Further, the price and accessibility of advanced neuroimaging technologies, particularly in resource-limited settings, may serve to put the brakes on MRI-informed treatment plans for schizophrenia becoming common (Jääskeläinen et al. 2018).

Nevertheless, our study offers evidence that neuroimaging can inform and personalize treatment for schizophrenia. To predict whether a patient will respond to their treatment on the basis of their brain characteristics is, it seems, a completely different game altogether. Future work should therefore concentrate on creating and validating clinically relevant algorithms that integrate multimodal imaging data to point treatment choices. To evaluate MRI-informed versus standard treatment options, future work will have to make more comprehensive comparisons and, if all goes well, through randomized controlled trials also. Beyond these difficulties, however, integration of MRI results into clinical settings has great potential for improving outcomes in this complex disorder.

Conclusion

This research shows that MRI findings have a major impact on schizophrenia treatment planning and also predicts the possible effect of such treatment. It was not exactly a surprise then that the high frequency of structural and functional brain abnormalities was confirmed by the MRI results. This reinforces the potential of neuroimaging to clarify why these normal activities fail. Specifically, there were changes by MRI review not only in medication but also in recommending cognitive remediation or pharmacological interventions. Cortical thickness in the dorsolateral prefrontal cortex emerges as a strong predictor for treatment response, and at the same time reflects the center of action figures on a trend line.

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