

Grammatical Analysis of Nastalique Writing Style of Urdu

Historical Note

Nastalique is one of the most intricate styles used for Arabic script, which makes it both beautiful and complex to model. This analysis has been conducted as part of the development process of Nafees Nastalique Font. The work has been conducted in 2002 and is being released for the general development of Nastalique writing style. The work has been supported by APDIP UNDP and IDRC.

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1. The Nastalique Style: An Introduction

Nastalique script is taken as a standard for writing Urdu language. It is also the most widely used script for Urdu. Though this script is defined by well-formed rules passed down through generations of calligraphers, these rules have not been quantitatively examined and published in enough detail to enable modeling of character-based Nastalique font for computers. This document aims to quantify these rules in significant detail to facilitate modeling and eventually implementation of Nastalique font.

Nastalique font is computationally complex for many reasons. First, letters are written using a flat nib (traditionally using bamboo pens) and both trajectory of the pen and angle of the nib define a glyph representing a letter. Each letter has precise writing rules, relative to the length of the flat nib. Second, this cursive font is highly context sensitive. Shape of a letter depends on multiple neighboring characters.

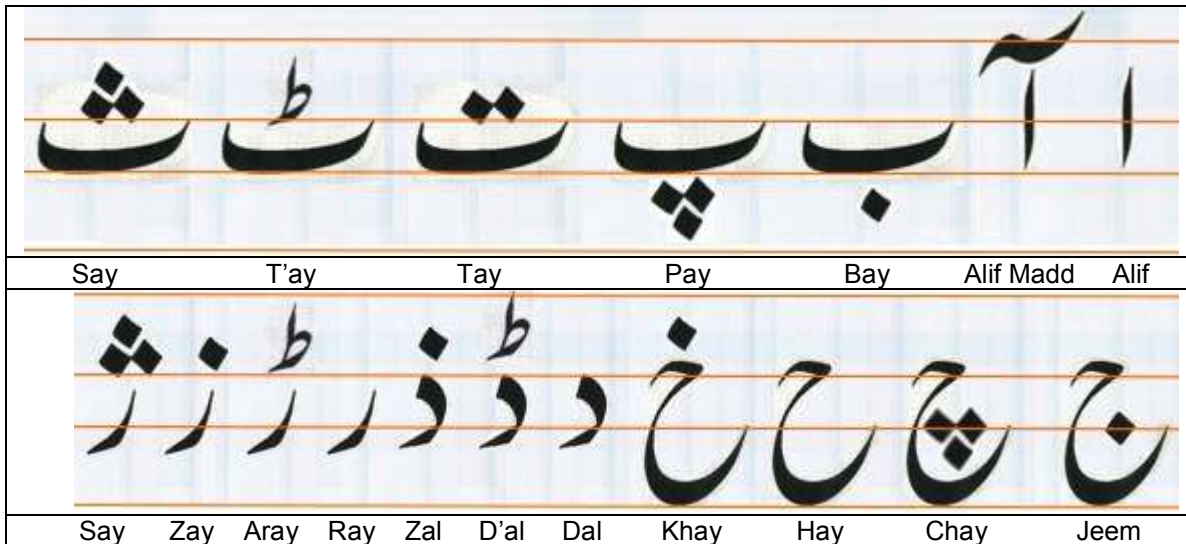
2. Urdu Script



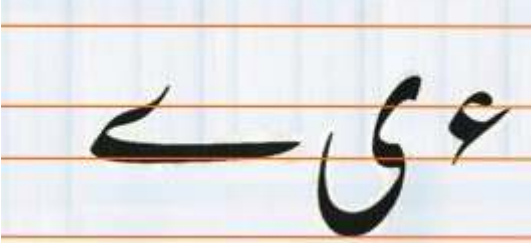
The Urdu alphabet is derived from the Arabic script which in itself is derived from the Aramaic script (Encarta 2000 Deluxe, Encyclopedia of Writing). In South Asia however Urdu language is written in two different scripts 'Devnagri' and 'Arabic'. In the parts of India, Urdu language has come under the influence of Hindi, borrowing its vocabulary as well as writing style from regional languages especially 'Sanskirat'. However, in Pakistan, Urdu has retained its Persio-Arabic influence and is written in Nastalique script. Nastalique is derived from two other styles of Arabic script 'Naskh' and 'Taleeq'. It was therefore named Naskh-Taleeq which gradually shortened to "Nastalique".

2.1. The Urdu Alphabet

The Urdu alphabet set is very similar to the Arabic alphabet. In fact most of the Arabic alphabets have been imported, as it is, in Urdu. The Urdu character set is phonetically more varied and hence contains additional alphabets influenced in major part by the Persian and the Sanskrit languages.

The Urdu alphabet is given below:



								
Ghain	Ain	Zuay	Tuay	Zuad	Suad	Sheen	Seen	
								
Hay	Wow	Noon	Meem	Lam	Gaf	Kaf	Qaf	Fay
								
					BariYeh	ChotiYeh	Hamza	

2.2. Mapping between Nastalique and Urdu characters

The Nastalique alphabets for Urdu have been adapted from their Arabic counterparts as in the Naskh and T'aleeq styles from which it has been derived. However, even for Urdu, this style is still taught with its original alphabet set. When the pupil gains mastery of the ligatures of this alphabet, then he/she is introduced to the modifications for Urdu.

Even aside from this fact, the alphabet set which is practiced in Nastalique does not contain the full Arabic alphabets. It is a systematic arrangement in which the characters are classified according to their shapes. The pupil strives first to master the characteristic shape of the class and then moves on to the variations.

The Nastalique to Urdu alphabet mapping can therefore be defined as below. Note that only the characters that are used in place of multiple similar shapes are shown. The rest of the characters in the alphabet are used without any such similar-shape classification.

	
--	---

ج چ ح خ	ج
د ڈ	د
ر ر ز ز	ر
س ش	س
ص ض	ص
ط ظ	ط
ع غ	ع
ک گ	ک

2.3. Building Blocks for an Urdu Font

In order to make a complete Urdu font, many characters, ligatures and symbols have to be available besides the alphabets. The following section describes the needed characters. The reference for these characters is the UZT (Urdu Zabta Takhti) 1.01, the standard code page for Urdu.

	0	1	2	3	4	5	6	7	8	9	a	b	c	d	e	f
0			Sp	•	⊗	ا	ژ	م			لله	O	[
1		×	ا	Hs	ا	ز	ن				۴		ا			
2		”	۲	ہمزہ اضافہ	آ	ژ	ن				بِسْمِ اللّٰہِ]			
3		✖	۳	کسرۃ اضافہ	ب	س	د				۵		Us			
4		Cr	۴	۱	پ	ش	ڈ				۶		{			
5		✖	۵	۱	ت	ص	ہ				۷		:			
6		✖	۶	۱	ث	ض	ق				۸		}			
7		۷	۷	۳	ث	ط	ء				۹		Da			
8		×	۸	=	ج	ظ	ی				۱۰					
9		×	۹	//	چ	ع	ے				۱۱					
a		×	:	//	ح	غ	ہ				۱۲					
b		×	۱۳	۱۳	خ	ف	خ				۱۴					
c		۱۴	×	۱۴	ط	د	ق	۱			۱۵					
d		-	×	۱۵	ڈ	ک	۱				۱۶					
e		Dc	×	۱۶	ذ	گ	۱				۱۷					×
f		Dv	۱۷	۱۷	ر	ل					۱۸					

Figure 1: Urdu Zabta Takhti (Urdu Code Plate) Ver 1.01

Abbreviations
 Sp: Space, Cr: currency, Dc: decimal, Dv: division,
 Hs: hard space, Us: underscore, Da: dash.
 —>: code plate switching

Legend

	Control area (not to be used)
	Reserved area (for future use by the standards)
	vendor area

Figure 1: UZT 1.01

All the Characters (above in UZT 1.01) which are not crossed needed for Urdu.

These characters are categorized into three groups:

- i) Normal characters (50 to 7A)
- ii) Diacritics (42 to 4F and 7B to 7E)
- iii) Special Characters (A0 to B0 and C7)
- iv) Numerical Characters (30 to 39)











A ligature of Muhammad should be in Urdu Character set. (Ref. Calligrapher Mr. Jameel)

Abbreviations:




- Sp (20) Space within the ligature.
- Hs (41) Space within the words.
- Dc (2E) Decimal point (different for Urdu than English e.g. small hamza is sometimes used for "ishariya" in Urdu).
- Dv (2F) Division sign or slash (/).
- Hamza-e-Izafat (42) Hamza used to connect words, e.g. in *Idara-e-Tehqiq*
- Kasr-e-Izafat (43) Zer used to connect words, e.g. in "Bang-e-Dera"
- Da (C7) Dash (in Urdu full stop is like a dash symbol)

2.3.1 Urdu Characters

All the characters of Urdu are listed in a sequential order below along with the UZT code and the Unicode.

Unicode Name	UZT Character Names	Glyphs	UZT code	Unicode
ARABIC LETTER ALIF	Alif		80	U0627
ARABIC LETTER ALIF WITH HAMZA ABOVE	Alif (hamza)		81	U0623
ARABIC LETTER ALIF WITH MADDA ABOVE	Alif mad		82	U0622
ARABIC LETTER BEH	Bay		83	U0628
ARABIC LETTER PEY	Pay		84	U067E
ARABIC LETTER TEH	Tay		85	U062A
ARABIC LETTER TTEH	Tae		86	U0679
ARABIC LETTER THEH	Say		87	U062B
ARABIC LETTER JEEM	Jeem		88	U062C
ARABIC LETTER TCHEH	Chay		89	U0686

ARABIC LETTER HAH	Hay	ح	90	U062D
ARABIC LETTER KHAH	Khay	خ	91	U062E
ARABIC LETTER DAL	Dal	د	92	U062F
ARABIC LETTER DDAL	Dhal	ط	93	U0688
ARABIC LETTER THAL	Zal	ذ	94	U0630
ARABIC LETTER REH	Ray	ر	95	U0631
ARABIC LETTER RREH	Array	ر	96	U0691
ARABIC LETTER ZAI	Zae	ز	97	U0632
ARABIC LETTER JEH	Yae	ي	98	U0698
ARABIC LETTER SEEN	Seen	س	99	U0633
ARABIC LETTER SHEEN	Sheen	ش	100	U0634
ARABIC LETTER SAD	Suad	ص	101	U0635
ARABIC LETTER DAD	Zuad	ض	102	U0636
ARABIC LETTER TAH	Toa	ط	103	U0637
ARABIC LETTER ZAH	Zoa	ظ	104	U0638
ARABIC LETTER AIN	Ain	ع	105	U0639
ARABIC LETTER GHAIN	Gain	غ	106	U063A
ARABIC LETTER FEH	Fay	ف	107	U0641
ARABIC LETTER QAF	Gaf	ق	108	U0642
ARABIC LETTER KEHEH	Kaf	ك	109	U06A9

ARABIC LETTER GAF	Ghaf		110	U06AF
ARABIC LETTER LAM	Lam		111	U0644
ARABIC LETTER MEEM	Meem		112	U0645
ARABIC LETTER NOON GHUNNA	Noon Ghunna		113	U06BA
ARABIC LETTER NOON	Noon		114	U0646
ARABIC LETTER WAO	Vao		115	U0648
ARABIC LETTER HAMZA ABOVE	Wao Hamza		116	U0624
ARABIC LETTER AE	Hay		117	U06D5
ARABIC LETTER TEH MARBUTA	Hay (Tay) as in zakat		118	U0629
ARABIC LETTER HAMZA	Hamza		119	U0621
ARABIC LETTER FARSI YEH	Yay		120	U06CC
ARABIC LETTER YEH BARREE	Yay (Bari)		121	U06D2
ARABIC LETTER HEH DOACHASHMEE	Hay (dochasmi)		122	U06BE

2.3.2 Punctuation and Arithmetic Symbols

Naskh includes its own set of punctuations in addition to the basic punctuations. These punctuations and other arithmetic symbols that are used with Naskh are listed below along with their respective UZT code and the Unicode.

Unicode Name	Glyph	UZT code	Unicode
SPACE		20	
EXCLAMATION MARK	!	21	U021
INVERTED COMMAS	"	22	U022
HASH SIGN	#	23	U023
CARRIAGE RETURN		24	
ARABIC PERCENTAGE SIGN	%	25	U066A
AMPERSAND SIGN	&	26	U026
APOSTROPHE	'	27	

OPENING BRACKET	(28	U028
CLOSING BRACKET)	29	U029
ARABIC FIVE POINTED STAR	*	2a	U066D
PLUS SIGN	+	2b	
ARABIC COMMA	‘	2c	U60C
HYPHEN	-	2d	
DECIMAL POINT	.	2e	U66B
DIVISION SYMBOL	/	2f	U02F
COLON	:	3a	U03A
COLON DASH	—	--	
SEMI COLON	؛	3B	U061B
LESS THAN SIGN	<	3c	U03C
IS EQUAL TO SIGN	=	3d	U03D
GREATER THAN SIGN	>	3e	U03E
QUESTION MARK	؟	3f	U61F
AT THE RATE OF SIGN	@	40	U040
HARD SPACE		41	

2.3.3 Digits

The digits in Urdu are written in a particular style in Naskh and they are written from left to right in contrast to the actual direction of writing that is from right to left. These digits along with their respective UZT code and Unicode are given below.

Unicode Name	UZT Character Name	Glyph	UZT code	Unicode
EXTENDED ARABIC-INDIC DIGIT ZERO	0	٠	30	U06F0
EXTENDED ARABIC-INDIC DIGIT ONE	1	١	31	U06F1
EXTENDED ARABIC-INDIC DIGIT TWO	2	٢	32	U06F2
EXTENDED ARABIC-INDIC DIGIT THREE	3	٣	33	U06F3
EXTENDED ARABIC-INDIC DIGIT FOUR	4	٤	34	U06F4
EXTENDED ARABIC-INDIC DIGIT FIVE	5	٥	35	U06F5
EXTENDED ARABIC-INDIC DIGIT SIX	6	٦	36	U06F6
EXTENDED ARABIC-INDIC DIGIT SEVEN	7	٧	37	U06F7
EXTENDED ARABIC-INDIC DIGIT EIGHT	8	٨	38	U06F8

EXTENDED ARABIC-INDIC DIGIT NINE	9	۹	39	U06F9
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2.3.4 Urdu Aerabs









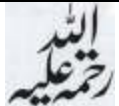

Every language has its own diacritics marks for the correct pronunciation of the words. This is true for Urdu as well. These marks are called Aerab in Urdu. Some of these Aerab are placed above the letter and some are placed below it for proper pronunciation of every letter. These Aerabs are listed below along with their corresponding UZT code and Unicode.






Unicode Name	UZT Character Name	Glyph	UZT code	Unicode
ARABIC HAMZA BELOW	Hamza-e-izafat	ء	42	U0655
ARABIC KASRA ISOLATED FORM	Kasre izafat	ِ	43	UFE7A
ARABIC LETTER SUPERSCRIPT ALEF	Khadi zabar	ا	44	U670
	Khadi zair	ا	45	0656
	Ulti paish	آ	46	0657
		آ	47	
			48	
ARABIC FATHATAN	Do zabar	اَ	49	U64B
ARABIC FATHATAN	Do zair	اِ	4a	U64D
ARABIC DAMMATAN	Do paish	اُ	4b	U64C
	Chota toein	اَ	4c	
ARABIC SMALL HIGH DOTLESS HEAD OF KHAH = Arabic Jazm	Jazm	ح	4D	U06E1
Noon Gunnah Symbol		ن	4E	0658
ARABIC SHADDA	Shad	ّ	4F	U0651
	Null diacritic	×	7b	
ARABIC FATHA	Zabar	اَ	7c	U064E
ARABIC KASRA	Zair	اِ	7d	U0650

ARABIC DAMMA	Pesh		7e	U064F
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2.3.5 Special symbols

Some symbols/ ligatures are used very often in writing Naskh. Due to this reason these special ligatures are included in the UZT as a whole ligature. Another reason for having these separate ligatures is that they are written in a special format. In the list below, all these symbols/ ligatures are listed along with the corresponding UZT Code and Unicode.

Unicode Name	UZT Character Name	Glyph	UZT code	Unicode
ARABIC LIGATURE ALLAH ISOLATED FORM	Lillah		A0	UFDF2
	Jale-jalalahu		A1	
	Bismillah		A2	FDF8
ARABIC LIGATURE SALLALLAHOU ALAYHE WASALLAM	Sallallahu-alehi-wa-alehi-wasallam (complete)		--	UF DFA
	Sallallahu-alehi-wa-alehi-wasallam (small)		A3	
ARABIC LIGATURE SALAM ISOLATED FORM	Sallallahu-alehi-wa-alehi-wasallam (symbol)		A4	0610
ARABIC LIGATURE ALAYHE ISOLATED FORM	Alehis-salam (symbol)		A5	U0611
	Raziallah-tallah-anhu (Complete)		--	
	Raziallah-tallah-anhu (symbol)		A6	0612
	Rahmet-ullah-aleh (Complete)		--	
	Rahmet-ullah-aleh (symbol)		A7	0613

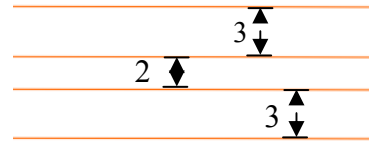
	Takhalus		A8	0614
	Misrah symbol		A9	
Poetic Verse Sign	Shair sign		AA	060D
Foot Note				0602
	Page Number		AB	
	Number symbol		AC	0600
SANAH	Year symbol		AD	0601
	Mada		AE	
ARABIC LIGATURE LAM WITH ALEF ISOLATED FORM	Laam alif		AF	UFEFB
	O	O	B0	
	Square bracket opening	[C0	U005B
	Back slash	\	C1	U005C
	Square bracket closing]	C2	U005D
	Underscore	_	C3	U005F
	Curly bracket opening	{	C4	U007B
	Colon	:	C5	
	Curly bracket closing	}	C6	U007D
	Dash		C7	U06D4

3. Nastalique Characters and Joins

3.1 Terminology Used in Nastalique

Terminologies commonly used in Nastalique are:

- **Qat:** is defined as horizontal distance (nib) of the calligraphic pen.
- **Kursi:** It can be related to the term baseline usually referred in typography. However, in Nastalique 'Kursi' is defined by four lines. Starting from top to bottom this document refers to them as line 1, line 2, line 3 and line 4 respectively.
 - Distance between line 1 and line 2 is three 'qat'.
 - Distance between line 2 and line 3 is two 'qat'.
 - Distance between line 3 and line 4 is three 'qat'.
- **Mad:** Extended lower flat part of Bay, Fay, Kaf and bari yeh may be called as 'Mad'.
- **Kashish:** Diagonal stroke as in letter sheen is called kashish.
- **Daman:** Lower circular arc of Jeen and Ain is generically known as Daman.
- **Daera:** Lower circular arc of Seen, Suad, Qaf, Noon and ChotiYeh, generically known as Daera (or circle).
- **Khamida:** Curved shape seen in shapes like *dal* is called *Khamida* shape.



3.2 Nastalique Tablets (Takhti)

The Nastalique characters and rules are conventionally categorized into 11 Takhties or tablets. First takhti is for the isolated characters (Mufridaat). The rest of tablets depict the rules of joining one character with each of the other characters in a two-character combination.

3.2.1 Isolated Tablet (Mufridaat Takhti)

The conventional tablet for the isolated character shapes of Nastalique is given as under:



3.2.2 Bay Tablet

The conventional tablet for the letter bay in Nastalique is given as under:



3.2.3 Jeem Tablet

The conventional tablet for the letter 'Jeem' in Nastalique is given as under:



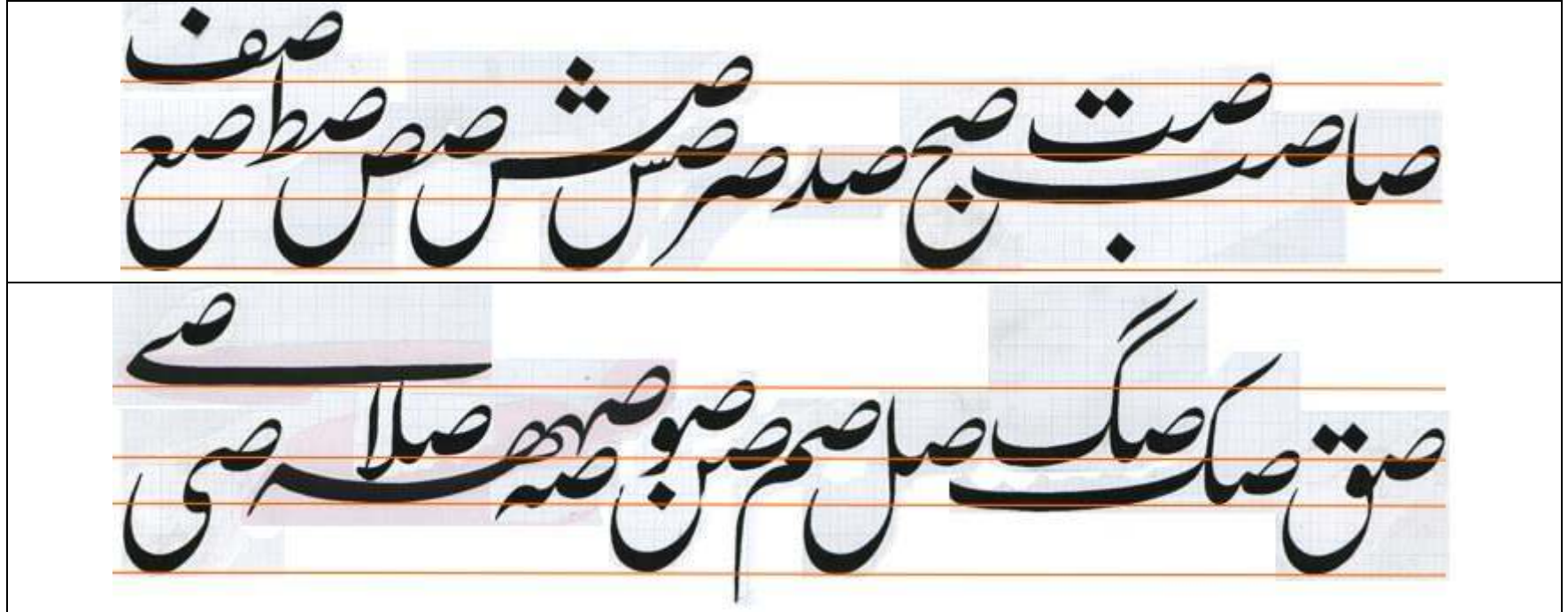
3.2.4 Seen Tablet

The conventional tablet for the letter 'Seen' in Nastalique is given below:



3.2.5 Suad Tablet

The conventional tablet for the letter 'Suad' in Nastalique is given as under:



3.2.6 Toay Tablet

The conventional tablet for the letter 'Toay' in Nastalique is given as under:



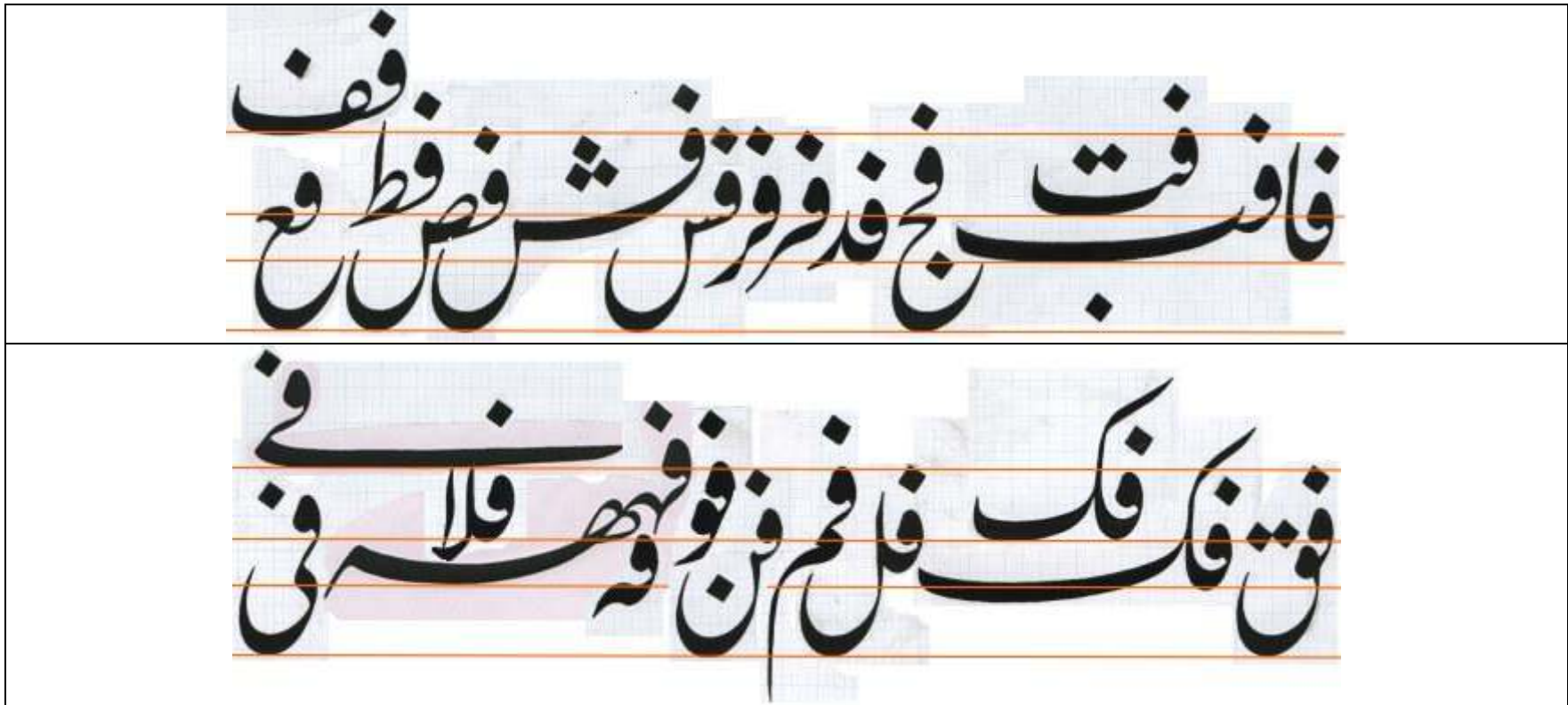
3.2.7 Ain Tablet

The conventional tablet for the letter 'Ain' in Nastalique is given as under:



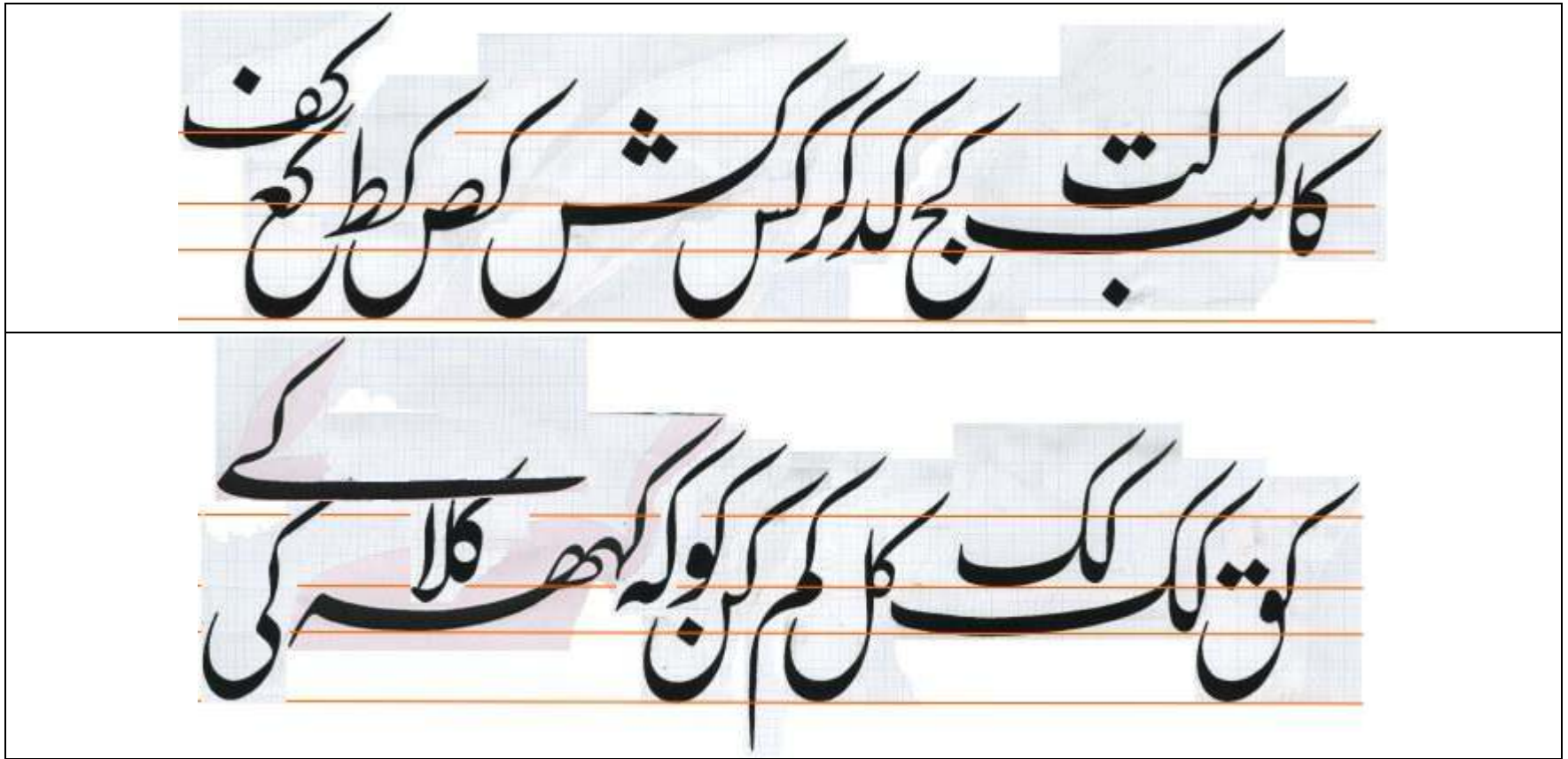
3.2.8 Fay Tablet

The conventional tablet for the letter 'Fay' in Nastalique is given as under:



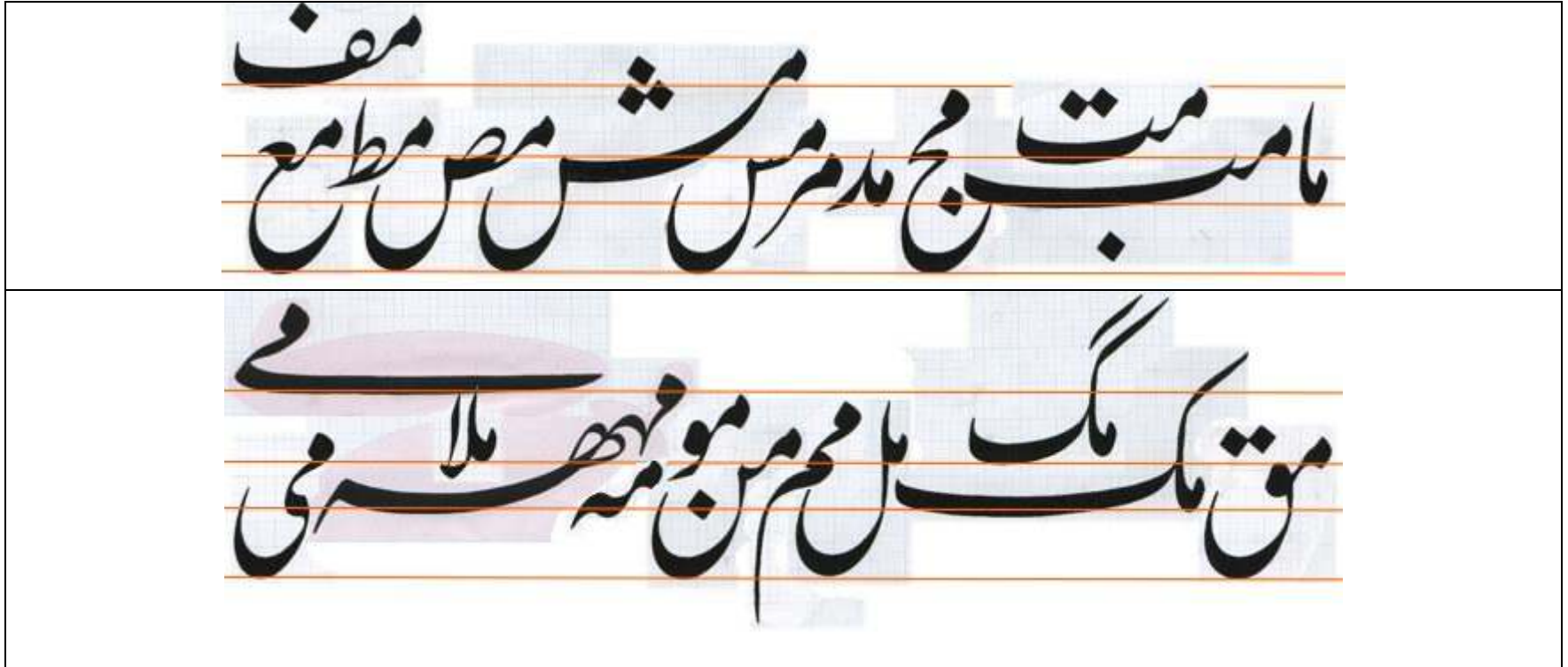
3.2.9 Kaf Tablet

The conventional tablet for the letter 'Kaf' in Nastalique is given as under:



3.2.10 Meem Tablet

The conventional tablet for the letter 'Meem' in Nastalique is given below:



3.2.11 Goal Hay Tablet

The conventional tablet for the letter 'Goal Hay' in Nastalique is given below:



3.3 Some Generalized Rules

In the following section, we present some generalized rules and constraints that have been brought out by the study of contextual shape dependency in Nastaliq characters.

3.3.1 The Role of Bay-Bay-All Tablet in 3-character ligature rules

It has been pointed out by the reference calligrapher, Mr. Jamil-ur-Rehman, that the most important tablet for the learning of character joinability in N-character ligatures is that of Bay-Bay-All. It defines the basic shape of most of the joins. Once such defined, these joins do not change their shapes by the substitution of other characters in place of Bay (i.e. the joins in ligatures of the type Bay-Bay-All, Bay-Any-All and Any-Any-All resemble one another to a considerable degree). There are only some exceptions to these rules.

The following section gives the images of the Bay-Bay-All tablet.

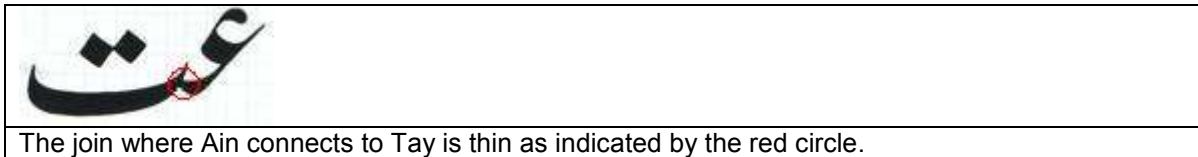
بن	ھ	ہل
ہلا	ہو	ہو
	ہے	ہی

3.3.2 The Nature of Joins in Nastalique

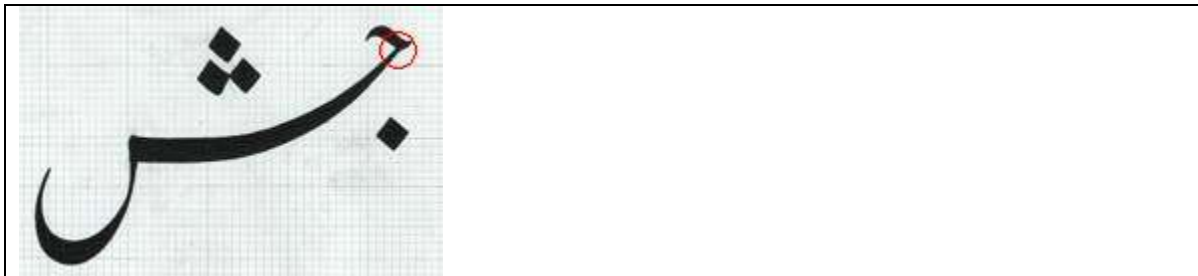
Nastalique is characterized by fine or fragile joins. That is to say, the joins in Nastalique i.e. the strokes where a character shape joins with another character, are thin. The character shapes themselves, are generally thick, at least thicker in most parts than the joins. Thus, there is an alternating sequence of thick and thin strokes in Nastalique ligatures.

The alternation of thick and thin strokes is not just an arbitrary rule. It has its basis in the perception or the reading of Nastalique text. In order to perceive the written Nastalique correctly and efficiently, with no eye strain, the scheme of alternating thick and thin joins is the best approach.

The fragile joins of Nastalique are illustrated below with some examples.



The join where Ain connects to Tay is thin as indicated by the red circle.



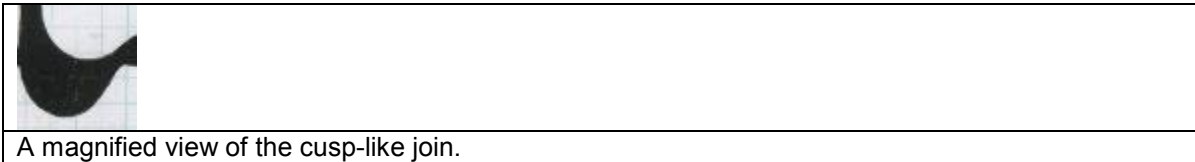
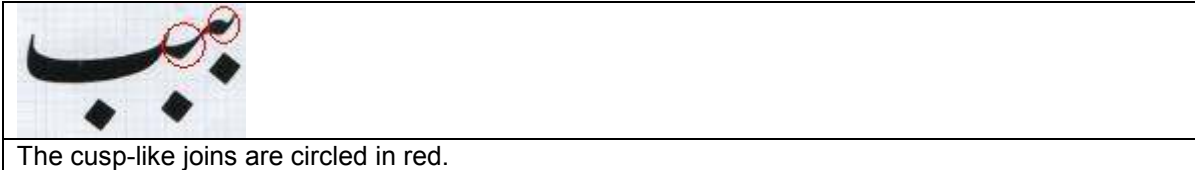
The join where Jeem connects to Sheen is thin as indicated by the red circle.

3.3.3 The Cusp-like Shape of Joins

Most of the joins in the Nastalique text are formed by cusp-like shapes which are concave upwards and have their initial end higher than the final end, hence, the overall effect of the join is to descend diagonally from the preceding character to the following one.

It is also to be borne in mind that the concavity of the cusp is such that the ends are vertical and the base of the cusp is horizontal. Thus, the cusp is concave upwards without any tilt to the vertical.

The cusp-like nature of the Nastalique joins are illustrated below with some examples.



3.3.4 Breaking the Monotony of Similar Joins

3.3.4.1. Variation in Shape of Join to Break Monotony

It is possible that many similar joins come together in a ligature, as in many Bay's connected to each other. In such a case, the similar shape of the joins renders it difficult to make out what is written i.e. the perception of the joins becomes difficult. That is why whenever similar cusp-like joins come together, the monotony of their shape is intentionally broken by differing the shape of alternate joins.

When two or more Bay's (or Bay-like joins) come together, every alternate join is raised to make it different from the surrounding ones. This helps in the perception i.e. reading of the Nastalique text.

The principle is illustrated below with some examples.



The raised join is shown in red circle.

3.3.4.2. Frequency of Usage of Raised Joins

It has been mentioned in the above section that the raised joins or raised cusps are used to break the monotony of the similar joins when several cusps come together. The frequency of usage of the raised and unraised joins is almost equal. Hence, a ligature can in principle be formed in either of the two ways: raised joins coming in between unraised ones and unraised joins coming in between raised ones. However, in practice, the first one is preferred as discussed below.



Starting with the unraised join, every second one is raised.



Starting with the raised join, every second one is unraised.

3.3.4.3. Minimization of Number of Raised Joins

The alternation of raised and unraised cusp-like joins is to be preferably constrained in such a way that the number of raised cusps is minimized.

This principle is illustrated with the following examples.



When six Bay's come together, the number of raised joins is minimized if we start with a raised join.

3.3.5. Shorthand-like Cases in Nastalique

Aside from the variety of the joins in Nastalique depending upon the preceding and following characters, there is yet another category of joins that denotes some cases which have shorthand-like properties.

In two-character ligatures a join comes between an initial and a final character shape and has no other function. However, in three-character ligatures a join might represent the third intervening character also. Hence in the Bay-Bay-Ray ligature illustrated below, there is no explicit shape of the middle Bay but the join between the initial and final characters has been slightly extended to indicate a third character in the middle. Furthermore, the nuqta of this middle bay below the extended join indicates the middle character.



Bay-Bay-Ray ligature with the join serving as the indication for the medial Bay.

It is also noteworthy that this property is heavily dependent on the perception of written text. That is why such an approach in some cases influences the preceding and following character shapes as well to avoid confusion in reading. This is illustrated in the following example.

It is also noteworthy that it is not necessary in some cases to make any change at all to any join or letter shape in the ligature except to introduce nuqtas or tuay. Thus the following ligature can be a two-character ligature and a three-character ligature depending upon the nuqtas.



Kaf-Say-Ray with the join indicating the middle Say. Note the use of long Ray to avoid confusion.



Kaf-Say with the short Say in the end. This has same structure as above but written differently to avoid confusion.



Jeem-Sheen, a 2-character ligature.



Jeem-Sheen-Noon, a 3-character ligature. Note that this differs only in the last extra nuqta from the above example.

3.3.6 Space Conservation in Nastalique

The diagonal nature of Nastalique, its inherent shorthand-like ligature formation cases, use of the nib of stylus at a steep angle to the trajectory and thin fragile joins, all combine to make Nastalique a most space-conserving style of writing. It is estimated that Nastalique takes approximately 40% less space than Naskh, the second popular style for writing Urdu (which resembles Roman style in the sense that each character shape is given a fixed width which usually does not change).

However, due to these same properties, the placement of nuqtas and diacritics in Nastalique text is a formidable challenge even for accomplished calligraphers. That is the reason Nastalique style is not usually used in the scribing of the Holy Quran.

3.3.7 Repeated Pattern of 2-character Joining in 3-character Ligatures

It has been observed in the analysis of 3-character ligatures that the rules of joining as in the 2-character ligatures have largely been reused. It is the following character that dictates the joining of the preceding one, whether it be in the third place as in 3-character ligatures or in the second place as in 2-character ligatures.

3.3.8 Repeated Pattern of 3-character Joining in 4-character Ligatures and beyond

The point here is similar to the one presented in above section. The rules of joining are largely reused from 3-character ligatures into the 4-character and longer ligatures. Once again, it is the following character that dictates the joining of the preceding one, whether it be in the second, third, fourth or any other place in the ligature.

4. Contextual Analysis of Nastalique

As in all Arabic scripts, in Nastalique shapes of a character vary depending on its position (initial, medial and final) in a ligature. In addition to position of character in a ligature, the character shape also depends on other characters of the ligature. Thus Nastalique is inherently context sensitive. This context sensitivity of Nastalique can be captured by substitution grammar as discussed in detail in this section.

For most medial shapes a barrage is inserted in flow of context sensitivity of grammar such that its preceding character's shape is not dependent on characters following the medial shape. Similarly glyphs that follow a medial shape are not dependent on what precedes it. Similarly, in most cases shapes of character occurring in final position of ligature are independent of their previous context. While preceding character depends on the next character. Thus, it may be concluded that rules for Nastalique predominately moves from left to right.

Also, for most cases initial shape is same for a character irrespective of the form (medial or final) of following character. For example shape of initial ج is same for final ج (i.e. جج) as well as medial ج as in ج ج ب ج ج ه and ج ج ع. Also shape of initial ب is same for final بس (i.e. بس) as well as medial س as in بس ا. Similar case is for جف and جفع. There are however few exceptions such as بين، بيش، ببس، بيچ etc. where the initial shape of ب is different from the one in بب.

This section lists the context sensitive grammar for characters occurring in initial, medial and final position of ligatures.

Explanation of Grammatical Conventions: The productions such as:

$\text{ب} \rightarrow \text{ب}_1 / \underline{\quad} \langle A \rangle \mid \underline{\quad} \text{ب}$

is to be read as ب transforms to ب_1 ($\text{ب} \rightarrow \text{ب}_1$), in the environment ($/$) when ب occurs before class A ($\underline{\quad} \langle A \rangle$) or ($|$) when ب occurs before ب ($\underline{\quad} \text{ب}$).

Note that 'OR' ($|$) operator has a higher precedence than 'Forward Slash' ($/$) operator. Thus, it would be possible to write multiple transformations in one environment using several 'OR' ($|$) operator on the right side of a single ($/$).

Also note that the underscore symbol ($\underline{\quad}$) is actually an indication of the position variable in a ligature. Hence, in the example above, $\underline{\quad}$ stands for ب_1 .

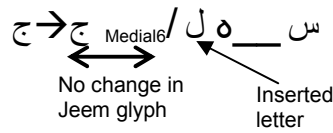
Explanation of grammar

As already mentioned above and also from analysis of 3-character and 4-character ligatures, one invariant that have predominantly existed in this contextual analysis of Nastalique is that *the shape of a character is mostly dependent on immediate preceding character*. That is given a ligature composed of character sequence X_1, X_2, \dots, X_N for $N > 2$, the shape of character X_i where $i < N$, is determined by letter X_{i+1} . While all preceding letters X_1, \dots, X_{i-1} and character sequences after its following character i.e X_{i+2}, \dots, X_N have no (or little) role in its shaping. Sequence of bay's form an exception to this general rule. Other exceptions are also mentioned.

Consider a rule for medial jeem in 3-character ligature:

$\text{ج} \rightarrow \text{ج} \text{Medial} / \text{ب} \underline{\quad} \text{س} \text{Final}$

From above argument the shape of jeem (ج_{Medial6}) is determined by final seen (س_{Final}) or simply seen (س) and not by ب or any preceding character. So changing ب to say ه and inserting any non-seperator before ه should have no effect on shape of Jeem. That is

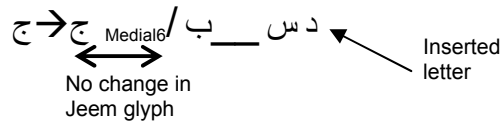


By introducing a class <NS> (short for Non-seperators), a general rule to specify the medial shape of jeem in 4-character ligature can be derived:

$$\text{ج} \rightarrow \text{ج} / \text{Medial6} / \langle \text{NS}_1 \rangle \langle \text{NS}_2 \rangle \text{س} \quad \text{Rule A}$$

Where <NS> → {ب ج س ص ط ع ف ق ك ل م ن ه ه م ی ے} i.e all charactares that can connect from front. <NS₁> are initial forms while <NS₂> are medial forms.

Also inserting any character after seen should have no effect on Jeem.



This leads to another rule to specify the medial shape on jeem in 4-character ligature.

$$\begin{aligned} &\text{ج} \rightarrow \text{ج} / \text{Medial6} / \text{ب} \text{س} \langle \text{All} \rangle \text{ or} \\ &\text{ج} \rightarrow \text{ج} / \text{Medial6} / \langle \text{NS} \rangle \text{س} \langle \text{All} \rangle \quad \text{Rule B} \end{aligned}$$

Where <All> → {ب ج د ر س ص ط ع ف ق ك ل م ن و ه ه م ی ے لا}. Class <All> is actually a set of charaters that can occur in final position. The analysis of these characters is presented in section 4.4.

N-character

The two rules can be combined to generalize for n-character ligature.

$$\text{ج} \rightarrow \text{ج} / \text{Medial6} / \langle \text{NS} \rangle \text{س} \langle \text{All} \rangle \quad \text{Rule B}$$

As after س any sequence of letters of any length can be appended without altering shape of Jeem, this rule can be rewritten as:

$$\begin{aligned} &\text{ج} \rightarrow \text{ج} / \text{Medial6} / \langle \text{NS} \rangle \text{س} \langle \text{NS} \rangle^+ \langle \text{All} \rangle \quad \text{Rule B.1} \\ &\text{ج} \rightarrow \text{ج} / \text{Medial6} / \langle \text{NS} \rangle \langle \text{NS} \rangle \text{س} \quad \text{Rule A} \end{aligned}$$

Combining these two yields:

$$\text{N characters: } \text{ج} \rightarrow \text{ج} / \text{Medial6} / \langle \text{NS} \rangle^+ \text{س} \langle \text{NS} \rangle^+ \langle \text{All} \rangle$$

Where superscript + indicates occurance of atleast one character and superscript * indicates 0 or more characters.

4.1 Classification of Characters with respect to Context

In Nastalique Urdu characters can also be classified with respect to certain features. One such feature is that of 'Kashish' (the elongation of character stroke). Class <Kashish> below mentions the letters which can be elongated.

<Kashish> → { ه ه م ف ع ص س ج }

In Nastalique letter 'meem' when occurring in medial position of a ligature has two alternative forms م and م_{Alt-1}. Only a selective number of letters can occur before alternative م_{Alt-1}. These letters have been grouped as <Char Before AlternativeMeem> below.

<Char Before AlternativeMeem> → { م ک ف ع ط ص س ج ب }

Classification of Glyphs occurring in Final Position

Following is a classification of final glyphs.

<A> → { ا_{Final} د_{Final} ک_{Final1} ک_{Final2} ل_{Final} لا_{Final} }

All glyphs of class <A>, except ل_{Final} forces their preceding characters to lie at line 3. While glyph ل_{Final} forces characters (glyphs) occurring before it to move two 'Qat' higher (i.e. at line 2).

<Ashort> → { ک_{Final1} ک_{Final2} }

A subset of class <A> (i.e. glyphs ا_{Final} ل_{Final} لا_{Final}) initiates a rounded version for the otherwise straight letter 'kaf'. Class <Ashort> describes the glyphs which do not initiate this change.

 → { ق_{Final} و_{Final} }

Classification of Glyphs occurring in non-Final Position

Classes defined below are drawn with respect to final characters. For example the class <Char

Before Ray1> → { ب_{Initial4} ج_{Initial4} ع_{Initial4} ف_{Initial4} ک_{Initial4} ل_{Initial4} ک_{Medial4} ل_{Medial4} } indicates all such character shapes that occur before final ray 1 (Initial and medial Glyphs before final ray 1).

<Char Before Ray1> → { ب_{Initial4} ج_{Initial4} ف_{Initial4} ک_{Initial4} ل_{Initial4} ک_{Medial4} ل_{Medial4} }

<Char Before Ray2> → { ج_{Initial5} س_{Initial5} ص_{Initial5} ط_{Initial5} ع_{Initial5} ف_{Initial5} م_{Initial5} ه_{Initial5} ه_{Initial5} }
 { ب_{Medial5} ج_{Medial5} س_{Medial5} ص_{Medial5} ط_{Medial5} ع_{Medial5} ف_{Medial5} م_{Medial5} ه_{Medial5} ه_{Medial5} }

<Char Before GoalHay1> → { ب_{Initial15} ج_{Initial15} س_{Initial15} ص_{Initial15} ف_{Initial15} ک_{Initial15} ل_{Initial15} م_{Initial15} ه_{Initial15} ه_{Initial15} ب_{Medial15} ج_{Medial15} س_{Medial15} ص_{Medial15} ف_{Medial15} ک_{Medial15} ل_{Medial15} م_{Medial15} ه_{Medial15} ه_{Medial15} }

<Char Before GoalHay2> → { ط_{Initial15} ع_{Initial15} ط_{Medial15} ع_{Medial15} }

<Char Before ChotiYeh1> → { ب_{Initial17} ف_{Initial17} ک_{Initial17} ل_{Initial17} ک_{Medial17} ل_{Medial17} }

<Char Before ChotiYeh2> → { ج_{Initial17-1} ج_{Initial17-2} س_{Initial17} ص_{Initial17} ط_{Initial17} ع_{Initial17} م_{Initial17} ه_{Initial17} ه_{Initial17} ب_{Medial17} ج_{Medial17} س_{Medial17} ص_{Medial17} ط_{Medial17} ع_{Medial17} ف_{Medial17} م_{Medial17} ه_{Medial17} ه_{Medial17} }

In the grammar discussed in this section others notations that are used are explained below.

Symbol <ج> indicates all non-final shapes of letter jeem.

Similarly symbols <ك>, <ل>, <س>, <س₂>, <ص>, <ط>, <ع>, <ف>, <م>, <ه>, <و> specify group of non-final glyphs for respective letter. Thus, symbol <م_{Alt-1}> show presence of any non-final glyph of

م_{Alt-1} in the context sensitive grammar given in this section.

<All> indicates all possible glyphs for each character.

<NS> indicates glyphs of those characters that can occur as non-seperator.

<NS>* indicates a sequence of zero or more non-seperator glyph(s).

<NS>⁺ indicates a sequence of atleast one non-seperator glyph(s).

<All-lam> indicates <All> minus <ل>

<NS-lam> indicates <NS> minus <ل>

4.2 Context Sensitive Grammar for Initial-Position characters:

4.2.1 Initial Bay

The following table lists the initial shapes of letter 'Bay'.

ب _{Initial1}	ب _{Initial2}	ب _{Initial3}	ب _{Initial4}	ب _{Initial6}
ب _{Initial7}	ب _{Initial8}	ب _{Initial9}	ب _{Initial10}	ب _{Initial11}
ب _{Initial12} [ب ₆]	ب _{Initial13}	ب _{Initial14}	ب _{Initial15}	ب _{Initial16}
ب _{Initial17}	ب _{Initial18}	ب _{Initial23}	ب _{Initial25}	ب _{Initial33}
ب _{Initial36}	ب _{Initial37}	ب _{Initial39}		

The Context in which these shapes occur is stated next:

ب → ب _{Initial1} / ___ <A> ___ <ك> <All-lam> ___ <ك> <NS-lam> <NS>* <All> ___ ل _{Final} ___ <ل> <NS>* <All> ___ ب ₂ <NS>* <All> ___ ب ₆ <NS>* <All> ___ ب ₁₄ <NS>* <All>	ب → ب _{Initial4} / ___ ر _{Final1} ب → ب _{Initial6} / ___ س _{Final1} ___ <س> <NS>* <All> ب → ب _{Initial7} / ___ س _{Final2} ___ <س ₂ > <NS>* <All> ب → ب _{Initial8} / ___ ص _{Final} ___ <ص> <NS>* <All> ب → ب _{Initial9} / ___ ط _{Final}
--	--

___ ب Medial23 <NS>*<All>	___ <ط><NS>*<All>
___ ب Medial25 <NS>*<All>	___ ل Final
___ ب Medial33 <NS>*<All>	___ <ل><NS>*<All>
___ ب Medial36 <NS>*<All>	ب → ب Initial10 / ___ ع Final
___ ب Medial37 <NS>*<All>	___ <ع><NS>*<All>
ب → ب Initial2 / ___ ب Final1	ب → ب Initial11 / ___ ف Final
___ ب Final2	___ <ف><NS>*<All>
___ ب Medial1 <NS>*<All>	ب → ب Initial12 / ___
___ ب Medial2 <NS>*<All>	ب → ب Initial13 / ___ م Final1
___ ب Medial8 <NS>*<All>	___ <م><NS>*<All>
___ ب Medial9 <NS>*<All>	ب → ب Initial14 / ___ ن Final
___ ب Medial10 <NS>*<All>	ب → ب Initial15 / ___ ه Final1
___ ب Medial11 <NS>*<All>	ب → ب Initial16 / ___ ه Final
___ ب Medial12 <NS>*<All>	___ <ه><NS>*<All>
___ ب Initial15 <NS>*<All>	___ <ه><NS>*<All>
___ ب Medial18 <NS>*<All>	ب → ب Initial17 / ___ ی Final1
ب → ب Initial3 / ___ ج Final	ب → ب Initial18 / ___ ے Final1
___ <ج><NS>*<All>	ب → ب Initial23 / ___ ب Medial3 <NS>*<All>
	ب → ب Initial25 / ___ ب Medial5 <All>
	ب → ب Initial33 / ___ ب Medial13 <NS>*<All>
	ب → ب Initial36 / ___ ب Medial16 <All>
	ب → ب Initial37 / ___ ب Medial17 <All>
	ب → ب Initial39 / ___ <م Alt-1><NS>*<All>

4.2.2 Initial Jeem

Given below are 19 initial shapes of letter 'Jeem'. Context in which these shapes occur is also mentioned below.

ج Initial1	ج Initial2	ج Initial3	ج Initial4	ج Initial5
ج Initial6	ج Initial7	ج Initial8	ج Initial9	ج Initial10

ج Initial11	ج Initial12 [ج6]	ج Initial13	ج Initial14	ج Initial15
ج Initial16 [ج13]	ج Initial17-1	ج Initial17-2	ج Initial18	ج Initial39

<p>ج → ج Initial1 / ___ <A> ___ <ك> <NS-Lam><NS>*<All> ___ <ك> <All-Lam> ___ <ل> <NS>*<All></p> <p>ج → ج Initial2 / ___ ب Final3 ___ ب Final4</p> <p>ج → ج Initial3 / ___ ج Final ___ <ج> <NS>*<All></p> <p>ج → ج Initial4 / ___ ر Final1</p> <p>ج → ج Initial5 / ___ ر Final2</p> <p>ج → ج Initial6 / ___ س Final1 ___ <س> <NS>*<All></p> <p>ج → ج Initial7 / ___ س Final2</p> <p>ج → ج Initial8 / ___ ص Final ___ <ص> <NS>*<All></p> <p>ج → ج Initial9 / ___ ط Final ___ <ط> <NS>*<All> ___ ل <ك> Final ___ ل <ك> <NS>*<All></p>	<p>ج → ج Initial10 / ___ ع Final ___ <ع> <NS>*<All></p> <p>ج → ج Initial11 / ___ ف Final ___ <ف> <NS>*<All></p> <p>ج → ج Initial12 / ___ </p> <p>ج → ج Initial13 / ___ م Final1 ___ <م> <NS>*<All></p> <p>ج → ج Initial14 / ___ ن Final</p> <p>ج → ج Initial15 / ___ ه Final1</p> <p>ج → ج Initial16 / ___ ه Final ___ <ه> <NS>*<All> ___ <ه> <NS>*<All></p> <p>ج → ج Initial17-1 / ___ ی Final2</p> <p>ج → ج Initial17-2 / ___ ی Final2</p> <p>ج → ج Initial18 / ___ ے Final1</p> <p>ج → ج Initial39 / ___ <م Alt-1> <NS>*<All></p>
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4.2.3 Initial Seen

Given below are 18 initial shapes of letter 'Seen'. Context in which these shapes occur is also mentioned below.

س Initial1	س Initial2	س Initial3	س Initial4	س Initial6
س Initial7	س Initial8	س Initial9	س Initial10	س Initial11

سInitial12	سInitial13	سInitial14	سInitial15	سInitial16
سInitial17	سInitial18-1	سInitial18-2	سInitial39	

<p>سInitial1 / ___ <A></p> <p> ___ <ك> <All-lam></p> <p> ___ <ك> <NS-lam> <NS>* <All></p> <p> ___ <ل> <NS>* <All></p> <p> ___ لFinal</p> <p> ___ ب2 <NS>* <All></p> <p> ___ ب6 <NS>* <All></p> <p> ___ بInitial14 <NS>* <All></p> <p> ___ بMedial2 <NS>* <All></p> <p> ___ بMedial8 <NS>* <All></p> <p> ___ بMedial9 <NS>* <All></p> <p> ___ بMedial10 <NS>* <All></p> <p> ___ بMedial12 <NS>* <All></p> <p> ___ بMedial23</p> <p> ___ بMedial25</p> <p> ___ بMedial33</p> <p> ___ بMedial36</p> <p> ___ بMedial37</p> <p>سInitial2 / ___ بFinal3 ___ بFinal4</p> <p>سInitial3 / ___ جFinal</p> <p> ___ <ج> <NS>* <All></p> <p>سInitial5 / ___ رFinal2</p> <p>سInitial6 / ___ سFinal1</p> <p> ___ <س> <NS>* <All></p> <p>سInitial7 / ___ سFinal2</p> <p>سInitial8 / ___ صFinal</p> <p> ___ <ص> <NS>* <All></p> <p>سInitial9 / ___ طFinal</p> <p> ___ <ط> <NS>* <All></p>	<p>سInitial10 / ___ عFinal</p> <p> ___ <ع> <NS>* <All></p> <p>سInitial11 / ___ فFinal</p> <p> ___ <ف> <NS>* <All></p> <p>سInitial12 / ___ </p> <p>سInitial13 / ___ مFinal1</p> <p> ___ <م> <NS>* <All></p> <p>سInitial14 / ___ نFinal</p> <p>سInitial15 / ___ هFinal1</p> <p>سInitial16 / ___ هFinal</p> <p> ___ <ه> <NS>* <All></p> <p> ___ <ه> <NS>* <All></p> <p>سInitial17 / ___ یFinal2</p> <p>سInitial18 / ___ ےFinal1</p> <p>سInitial21 / ___ بMedial1 <NS>* <All></p> <p> ___ بInitial15 <NS>* <All></p> <p> ___ بMedial16 <NS>* <All></p> <p> ___ بMedial18 <NS>* <All></p> <p>سInitial39 / ___ مAlt-1 <NS>* <All></p>
---	--

ل Final <ک>	
ل <NS>* <ک>	

4.2.4 Initial Suad

Given below are 17 initial shapes of letter 'Suad'. Context in which these shapes occur is also mentioned below.

ص Initial1	ص Initial2	ص Initial3	ص Initial4	ص Initial6
ص Initial7	ص Initial8	ص Initial9	ص Initial10	ص Initial11
ص Initial12	ص Initial13	ص Initial14	ص Initial15	ص Initial16 [ص13]
ص Initial17	ص Initial18	ص Initial39		

ص → ص Initial1 / ___ <A> ___ <ک> <All-lam> ___ <ک> <NS-lam> <NS>* <All> ___ <ل> <NS>* <All> ___ ل Final ___ ب ₂ <NS>* <All> ___ ب ₆ <NS>* <All> ___ ب ₁₄ <NS>* <All> ___ ب _{Medial2} <NS>* <All> ___ ب _{Medial8} <NS>* <All> ___ ب _{Medial9} <NS>* <All> ___ ب _{Medial10} <NS>* <All> ___ ب _{Medial12} <NS>* <All> ___ ب _{Medial23} ___ ب _{Medial25}	ص → ص Initial10 / ___ ع Final ___ <ع> <NS>* <All> ص → ص Initial11 / ___ ف Final ___ <ف> <NS>* <All> ص → ص Initial12 / ___ ص → ص Initial13 / ___ م Final1 ___ <م> <NS>* <All> ص → ص Initial14 / ___ ن Final ص → ص Initial15 / ___ ه Final1 ص → ص Initial16 / ___ ه Final ___ <ه> <NS>* <All> ___ <ه> <NS>* <All> ص → ص Initial17 / ___ ی Final2 ص → ص Initial18 / ___ ے Final1 ص → ص Initial21 / ___ ب _{Medial1} <NS>* <All>
--	--

___ ب _{Medial33} ___ ب _{Medial36} ___ ب _{Medial37} ص → ص _{Initial2} / ___ ب _{Final3} ___ ب _{Final4} ص → ص _{Initial3} / ___ ج _{Final} ___ <ج> <NS>* <All> ص → ص _{Initial5} / ___ ر _{Final2} ص → ص _{Initial6} / ___ س _{Final1} ___ <س> <NS>* <All> ص → ص _{Initial7} / ___ س _{Final2} ص → ص _{Initial8} / ___ ص _{Final} ___ <ص> <NS>* <All> ص → ص _{Initial9} / ___ ط _{Final} ___ <ط> <NS>* <All> ___ ل _{Final} <ك> ___ <ل> <NS>* <All>	___ ب ₁₅ <NS>* <All> ___ ب _{Medial16} <NS>* <All> ___ ب _{Medial18} <NS>* <All> ص → ص _{Initial39} / ___ م _{Alt-1} <NS>* <All>
--	--

4.2.5 Initial Toay

Given below are 17 initial shapes of letter 'Toay'. Context in which these shapes occur is also mentioned below.



















ط _{Initial1}	ط _{Initial2}	ط _{Initial3}	ط _{Initial4}	ط _{Initial6}
ط _{Initial7}	ط _{Initial8}	ط _{Initial9}	ط _{Initial10}	ط _{Initial11}
ط _{Initial12}	ط _{Initial13}	ط _{Initial14}	ط _{Initial15}	ط _{Initial16} [ط ₁₃]

ط _{Initial17}	ط _{Initial18}	ط _{Initial39}
------------------------	------------------------	------------------------

ط → ط _{Initial1} / ___ <A> ___ <ك> <NS-Lam><NS>*<All> ___ <ك> <All-Lam> ___ <ل> <NS>*<All> ط → ط _{Initial2} / ___ ب _{Final3} ___ ب _{Final4} ط → ط _{Initial3} / ___ ج _{Final} ___ <ج> <NS>*<All> ط → ط _{Initial5} / ___ ر _{Final2} ط → ط _{Initial6} / ___ س _{Final1} ___ <س> <NS>*<All> ط → ط _{Initial7} / ___ س _{Final2} ط → ط _{Initial8} / ___ ص _{Final} ___ <ص> <NS>*<All> ط → ط _{Initial9} / ___ ط _{Final} ___ <ط> <NS>*<All> ___ ل _{Final} <ك> ___ <ل> <NS>*<All>	ط → ط _{Initial10} / ___ ع _{Final} ___ <ع> <NS>*<All> ط → ط _{Initial11} / ___ ف _{Final} ___ <ف> <NS>*<All> ط → ط _{Initial12} / ___ ط → ط _{Initial13} / ___ م _{Final1} ___ <م> <NS>*<All> ط → ط _{Initial14} / ___ ن _{Final} ط → ط _{Initial15} / ___ ه _{Final2} ط → ط _{Initial16} / ___ ه _{Final} ___ <ه> <NS>*<All> ___ <ه> <NS>*<All> ط → ط _{Initial17} / ___ ی _{Final2} ط → ط _{Initial18} / ___ ے _{Final1} ط → ط _{Initial39} / ___ <م_{Alt-1}> <NS>*<All>
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4.2.6 Initial Ain

Given below are 17 initial shapes of letter 'Ain'. Context in which these shapes occur is also mentioned below.

				
ع _{Initial1}	ع _{Initial2}	ع _{Initial3}	ع _{Initial4}	ع _{Initial6}
				
ع _{Initial 7}	ع _{Initial8}	ع _{Initial9}	ع _{Initial10}	ع _{Initial11}
				
ع _{Initial12}	ع _{Initial13}	ع _{Initial14}	ع _{Initial15}	ع _{Initial16}
				
ع _{Initial17}	ع _{Initial18}	ع _{Initial39}		

ع → ع ^{Initial1} / ___ <A> ___ <ك> <NS-Lam><NS>*<All> ___ <ك> <All-Lam> ___ <ل> <NS>*<All>	ع → ع ^{Initial10} / ___ ع ^{Final} ___ <ع> <NS>*<All>
ع → ع ^{Initial2} / ___ ب ^{Final3} ___ ب ^{Final4} ع → ع ^{Initial3} / ___ ج ^{Final} ___ <ج> <NS>*<All>	ع → ع ^{Initial11} / ___ ف ^{Final} ___ <ف> <NS>*<All>
ع → ع ^{Initial5} / ___ ر ^{Final2} ع → ع ^{Initial6} / ___ س ^{Final1} ___ <س> <NS>*<All>	ع → ع ^{Initial12} / ___ ع → ع ^{Initial13} / ___ م ^{Final1} ___ <م> <NS>*<All>
ع → ع ^{Initial7} / ___ س ^{Final2} ع → ع ^{Initial8} / ___ ص ^{Final} ___ ص <NS>*<All>	ع → ع ^{Initial14} / ___ ن ^{Final} ع → ع ^{Initial15} / ___ ه ^{Final2} ع → ع ^{Initial16} / ___ ه ^{Final} ___ <ه> <NS>*<All> ___ <ه> <NS>*<All>
ع → ع ^{Initial9} / ___ ط ^{Final} ___ <ط> <NS>*<All> ___ ل ^{Final} <ك> ___ ل <ك> <NS>*<All>	ع → ع ^{Initial17} / ___ ی ^{Final2} ع → ع ^{Initial18} / ___ ے ^{Final1} ع → ع ^{Initial39} / ___ م ^{Alt-1} <NS>*<All>

4.2.7 Initial Fay

Given below are 19 initial shapes of letter 'Fay'. Context in which these shapes occur is also mentioned below. For initial and medial position base shapes for fay and qaf are same.











ف ^{Initial1}	ف ^{Initial2-1}	ف ^{Initial2-2}	ف ^{Initial3}	ف ^{Initial4}
ف ^{Initial5}	ف ^{Initial6}	ف ^{Initial7}	ف ^{Initial8}	ف ^{Initial9}
ف ^{Initial10}	ف ^{Initial11}	ف ^{Initial12}	ف ^{Initial13}	ف ^{Initial14}
ف ^{Initial15}	ف ^{Initial16}	ف ^{Initial17}	ف ^{Initial18}	ف ^{Initial39}

<p>ف → ف_{Initial1} / ___ <A> ___ <ك> <NS-Lam><NS>*<All> ___ <ك> <All-Lam> ___ <ل> <NS>*<All></p> <p>ف → ف_{Initial2} / ___ ب_{Final3} ___ ب_{Final4}</p> <p>ف → ف_{Initial3} / ___ ج_{Final} ___ <ج> <NS>*<All></p> <p>ف → ف_{Initial4} / ___ ر_{Final1}</p> <p>ف → ف_{Initial5} / ___ ر_{Final2}</p> <p>ف → ف_{Initial6} / ___ س_{Final1} ___ <س> <NS>*<All></p> <p>ف → ف_{Initial7} / ___ س_{Final2}</p> <p>ف → ف_{Initial8} / ___ ص_{Final} ___ <ص> <NS>*<All></p> <p>ف → ف_{Initial9} / ___ ط_{Final} ___ <ط> <NS>*<All> ___ ل_{Final} <ك> ___ ل <NS>*<All></p>	<p>ف → ف_{Initial10} / ___ ع_{Final} ___ <ع> <NS>*<All></p> <p>ف → ف_{Initial11} / ___ ف_{Final} ___ <ف> <NS>*<All></p> <p>ف → ف_{Initial12} / ___ </p> <p>ف → ف_{Initial13} / ___ م_{Final1} ___ <م> <NS>*<All></p> <p>ف → ف_{Initial14} / ___ ن_{Final}</p> <p>ف → ف_{Initial15} / ___ ه_{Final1}</p> <p>ف → ف_{Initial16} / ___ ه_{Final} ___ <ه> <NS>*<All> ___ <ه> <NS>*<All></p> <p>ف → ف_{Initial17} / ___ ی_{Final1}</p> <p>ف → ف_{Initial18} / ___ م_{Final1}</p> <p>ف → ف_{Initial39} / ___ <م Alt-1> <NS>*<All></p>
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4.2.8 Initial Kaf

Given below are 19 initial shapes of letter 'Kaf'. Context in which these shapes occur is also mentioned below. For initial and medial position base shapes for kaf and gaf are same. In most cases, by removing initial diagonal stroke from kaf results in character lam. However, separate analysis of lam is given in 4.2.9.

ک _{Initial1-1}	ک _{Initial2-1-1}	ک _{Initial2-1-2}	ک _{Initial3-1}	ک _{Initial4-1}
ک _{Initial6-1}	ک _{Initial7-1}	ک _{Initial8-1}	ک _{Initial9-1}	ک _{Initial10-1}

				
ک _{Initial11-1}	ک _{Initial12-1}	ک _{Initial13-1} [ک ₁₂]	ک _{Initial14-1}	ک _{Initial15-1}
				
ک _{Initial16-1} [ک ₁₃]	ک _{Initial17-1}	ک _{Initial18-1}	ک _{Initial19-1}	ک _{Initial20-1}

<p>ک → ک_{Initial1-1} / ___ Final ___ لا_{Final} ___ <ل> <NS>* <All></p> <p>ک → ک_{Initial2} / ___ ب_{Final3} ___ ب_{Final4}</p> <p>ک → ک_{Initial3} / ___ ج_{Final} ___ <ج> <NS>* <All></p> <p>ک → ک_{Initial5} / ___ ر_{Final1}</p> <p>ک → ک_{Initial6} / ___ س_{Final1} ___ <س> <NS>* <All></p> <p>ک → ک_{Initial7} / ___ س_{Final2}</p> <p>ک → ک_{Initial8} / ___ ص_{Final} ___ <ص> <NS>* <All></p> <p>ک → ک_{Initial9} / ___ ط_{Final} ___ <ط> <NS>* <All> ___ ل_{Final} <ک> ___ ل <NS>* <All></p>	<p>ک → ک_{Initial10} / ___ ع_{Final} ___ <ع> <NS>* <All></p> <p>ک → ک_{Initial11} / ___ ف_{Final} ___ <ف> <NS>* <All></p> <p>ک → ک_{Initial12} / ___ </p> <p>ک → ک_{Initial13} / ___ م_{Final1} ___ <م> <NS>* <All></p> <p>ک → ک_{Initial14} / ___ ن_{Final}</p> <p>ک → ک_{Initial15} / ___ ه_{Final1}</p> <p>ک → ک_{Initial16} / ___ ه_{Final} ___ <ه> <NS>* <All> ___ <ه> <NS>* <All></p> <p>ک → ک_{Initial7} / ___ ی_{Final1}</p> <p>ک → ک_{Initial18} / ___ ے_{Final1}</p> <p>ک → ک_{Initial19-1} / ___ <Ashort> ___ د_{Final} ___ <ک> <NS-Lam> <NS>* <All> ___ <ک> <All-Lam></p> <p>ک → ک_{Initial20-1} / ___ ل_{Final}</p>
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4.2.9 Initial Lam



















Given below are 17 initial shapes of letter 'Lam'. Context in which these shapes occur is also mentioned below.

ل _{Initial1} [ل ₁₃]	ل _{Initial2-1}	ل _{Initial2-2}	ل _{Initial3}	ل _{Initial4}	ل _{Initial6}
ل _{Initial7}	ل _{Initial8}	ل _{Initial9}	ل _{Initial10}	ل _{Initial11}	ل _{Initial12}
ل _{Initial13}	ل _{Initial14}	ل _{Initial15}	ل _{Initial16}	ل _{Initial17}	ل _{Initial18}

<p>لا + ا → لا Ligature</p> <p>ل → ل_{Initial1} / ___ <ك> <NS-Lam> <NS>* <All></p> <p> ___ <ك> <All-Lam></p> <p> ___ <ل> <NS>* <All></p> <p> ___ د_{Final} ___ ك_{Final1}</p> <p> ___ ك_{Final2}</p> <p> ___ ل_{Final} ___ لا_{Final}</p> <p>ل → ل_{Initial2} / ___ ب_{Final3} ___ ب_{Final4}</p> <p>ل → ل_{Initial3} / ___ ج_{Final}</p> <p> ___ <ج> <NS>* <All></p> <p>ل → ل_{Initial5} / ___ ر_{Final1}</p> <p>ل → ل_{Initial 6} / ___ س_{Final1}</p> <p> ___ <س> <NS>* <All></p> <p>ل → ل_{Initial 7} / ___ س_{Final2}</p> <p>ل → ل_{Initial 8} / ___ ص_{Final}</p> <p> ___ <ص> <NS>* <All></p> <p>ل → ل_{Initial 9} / ___ ط_{Final}</p> <p> ___ <ط> <NS>* <All></p> <p> ___ ل_{Final} <ك></p> <p> ___ ل_{Final} <ك> <NS>* <All></p>	<p>ل → ل_{Initial10} / ___ ع_{Final}</p> <p> ___ <ع> <NS>* <All></p> <p>ل → ل_{Initial11} / ___ ف_{Final}</p> <p> ___ <ف> <NS>* <All></p> <p>ل → ل_{Initial12} / ___ </p> <p>ل → ل_{Initial13} / ___ م_{Final1}</p> <p> ___ <م> <NS>* <All></p> <p>ل → ل_{Initial14} / ___ ن_{Final}</p> <p>ل → ل_{Initial15} / ___ ه_{Final1}</p> <p>ل → ل_{Initial16} / ___ ه_{Final}</p> <p> ___ <ه> <NS>* <All></p> <p> ___ <ه> <NS>* <All></p> <p>ل → ل_{Initial17} / ___ ي_{Final1}</p> <p>ل → ل_{Initial18} / ___ ع_{Final1}</p>
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4.2.10 Initial Meem

Given below are 17 initial shapes of letter 'Meem'. Context in which these shapes occur is also mentioned below.

				
Initial1	Initial2	Initial3	Initial4	Initial6
				
Initial7	Initial8	Initial9	Initial10	Initial11
				
Initial12	Initial13	Initial14	Initial15	Initial16 [م 13]
				
Initial17	Initial18	Initial39		

<p> $\text{م} \rightarrow \text{م}_1 / \underline{\quad} \langle \text{A} \rangle$ $\quad \underline{\quad} \langle \text{ك} \rangle \langle \text{NS-Lam} \rangle \langle \text{NS} \rangle^* \langle \text{All} \rangle$ $\quad \underline{\quad} \langle \text{ك} \rangle \langle \text{All-Lam} \rangle$ $\quad \underline{\quad} \langle \text{ل} \rangle \langle \text{NS} \rangle^* \langle \text{All} \rangle$ </p> <p> $\text{م} \rightarrow \text{م}_{\text{Initial 2}} / \underline{\quad} \text{ب}_{\text{Final 3}} \underline{\quad} \text{ب}_{\text{Final 4}}$ </p> <p> $\text{م} \rightarrow \text{م}_{\text{Initial 3}} / \underline{\quad} \text{ج}_{\text{Final}}$ $\quad \underline{\quad} \langle \text{ج} \rangle \langle \text{NS} \rangle^* \langle \text{All} \rangle$ </p> <p> $\text{م} \rightarrow \text{م}_{\text{Initial 5}} / \underline{\quad} \text{ر}_{\text{Final 2}}$ </p> <p> $\text{م} \rightarrow \text{م}_{\text{Initial 6}} / \underline{\quad} \text{س}_{\text{Final 1}}$ $\quad \underline{\quad} \langle \text{س} \rangle \langle \text{NS} \rangle^* \langle \text{All} \rangle$ </p> <p> $\text{م} \rightarrow \text{م}_{\text{Initial 7}} / \underline{\quad} \text{س}_{\text{Final 2}}$ </p> <p> $\text{م} \rightarrow \text{م}_{\text{Initial 8}} / \underline{\quad} \text{ص}_{\text{Final}}$ $\quad \underline{\quad} \langle \text{ص} \rangle \langle \text{NS} \rangle^* \langle \text{All} \rangle$ </p> <p> $\text{م} \rightarrow \text{م}_{\text{Initial 9}} / \underline{\quad} \text{ط}_{\text{Final}}$ $\quad \underline{\quad} \langle \text{ط} \rangle \langle \text{NS} \rangle^* \langle \text{All} \rangle$ $\quad \underline{\quad} \text{ل}_{\text{Final}} \langle \text{ك} \rangle$ $\quad \underline{\quad} \langle \text{ك} \rangle \langle \text{NS} \rangle^* \langle \text{All} \rangle$ </p>	<p> $\text{م} \rightarrow \text{م}_{\text{Initial 10}} / \underline{\quad} \text{ع}_{\text{Final}}$ $\quad \underline{\quad} \langle \text{ع} \rangle \langle \text{NS} \rangle^* \langle \text{All} \rangle$ </p> <p> $\text{م} \rightarrow \text{م}_{\text{Initial 11}} / \underline{\quad} \text{ف}_{\text{Final}}$ $\quad \underline{\quad} \langle \text{ف} \rangle \langle \text{NS} \rangle^* \langle \text{All} \rangle$ </p> <p> $\text{م} \rightarrow \text{م}_{\text{Initial 12}} / \underline{\quad} \langle \text{B} \rangle$ </p> <p> $\text{م} \rightarrow \text{م}_{\text{Initial 13}} / \underline{\quad} \text{م}_{\text{Final 1}}$ $\quad \underline{\quad} \langle \text{م} \rangle \langle \text{NS} \rangle^* \langle \text{All} \rangle$ </p> <p> $\text{م} \rightarrow \text{م}_{\text{Initial 14}} / \underline{\quad} \text{ن}_{\text{Final}}$ </p> <p> $\text{م} \rightarrow \text{م}_{\text{Initial 15}} / \underline{\quad} \text{ه}_{\text{Final 1}}$ </p> <p> $\text{م} \rightarrow \text{م}_{\text{Initial 16}} / \underline{\quad} \text{ه}_{\text{Final}}$ $\quad \underline{\quad} \langle \text{ه} \rangle \langle \text{NS} \rangle^* \langle \text{All} \rangle$ $\quad \underline{\quad} \langle \text{ه} \rangle \langle \text{NS} \rangle^* \langle \text{All} \rangle$ </p> <p> $\text{م} \rightarrow \text{م}_{\text{Initial 17}} / \underline{\quad} \text{ى}_{\text{Final 2}}$ </p> <p> $\text{م} \rightarrow \text{م}_{\text{Initial 18}} / \underline{\quad} \text{ے}_{\text{Final 1}}$ </p> <p> $\text{م} \rightarrow \text{م}_{\text{Initial 39}} / \underline{\quad} \langle \text{م}_{\text{Alt-1}} \rangle \langle \text{NS} \rangle^* \langle \text{All} \rangle$ </p>
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4.2.11 Initial Goal Hay

Given below are 17 initial shapes of letter 'Goal Hay'. Context in which these shapes occur is also mentioned below.


















In written text ('tehrir') hook diacritic is used below all initial shapes of Goal Hay. With the exception of hook occurring in ligature 'Goal-Hay + Alif'; all other hooks are written with another pen whose 'qat' size is half the qat size of pen with which base ligature is written. Ligature 'Goal-Hay + Alif' is written with the same pen as the base ligature itself. For each ligature diacritic hook is placed below goal hay's cup ('shosha').

◌Initial1	◌Initial2	◌Initial3	◌Initial5-1	◌Initial5-2
◌Initial6	◌Initial7	◌Initial8	◌Initial9	◌Initial10
◌Initial11	◌Initial12	◌Initial13	◌Initial14	◌Initial15[◌13]
◌Initial16[◌13]	◌Initial7	◌Initial18	◌Initial39	

<p>◌ → ◌_{Initial1} / ___ <A> ___ <ك> <NS-Lam><NS>*<All> ___ <ك> <All-Lam> ___ <ل> <NS>*<All></p> <p>◌ → ◌_{Initial2} / ___ ب_{Final3} ___ ب_{Final4}</p> <p>◌ → ◌_{Initial3} / ___ ج_{Final} ___ <ج> <NS>*<All></p> <p>◌ → ◌_{Initial5} / ___ ر_{Final2}</p> <p>◌ → ◌_{Initial6} / ___ س_{Final1} ___ <س> <NS>*<All></p> <p>◌ → ◌_{Initial7} / ___ س_{Final2}</p> <p>◌ → ◌_{Initial8} / ___ ص_{Final} ___ <ص> <NS>*<All></p> <p>◌ → ◌_{Initial9} / ___ ط_{Final} ___ <ط> <NS>*<All> ___ <ك> ل_{Final} ___ <ك> ل <NS>*<All></p>	<p>◌ → ◌_{Initial10} / ___ ع_{Final} ___ <ع> <NS>*<All></p> <p>◌ → ◌_{Initial11} / ___ ف_{Final} ___ <ف> <NS>*<All></p> <p>◌ → ◌_{Initial12} / ___ </p> <p>◌ → ◌_{Initial13} / ___ م_{Final1} ___ <م> <NS>*<All></p> <p>◌ → ◌_{Initial14} / ___ ن_{Final}</p> <p>◌ → ◌_{Initial15} / ___ ه_{Final1}</p> <p>◌ → ◌_{Initial16} / ___ ه_{Final} ___ <ه> <NS>*<All> ___ <ه> <NS>*<All></p> <p>◌ → ◌_{Initial17} / ___ ی_{Final2}</p> <p>◌ → ◌_{Initial18} / ___ ے_{Final1}</p> <p>◌ → ◌_{Initial39} / ___ م_{Alt-1} <NS>*<All></p>
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4.2.11 Initial Do Chashmi Hay

Given below are 17 initial shapes of letter 'Do Chashmi Hay'. Context in which these shapes occur is also mentioned below.

				
ه _{Initial1}	ه _{Initial2}	ه _{Initial3}	ه _{Initial4}	ه _{Initial6}
				
ه _{Initial7}	ه _{Initial8}	ه _{Initial9}	ه _{Initial10}	ه _{Initial11}
				
ه _{Initial12}	ه _{Initial13}	ه _{Initial14}	ه _{Initial15}	ه _{Initial16}
				
ه _{Initial17}	ه _{Initial18}	ه _{Initial19}		

<p>ه → ه_{Initial1} / ___ <A> ___ <ك> <NS-Lam><NS>*<All> ___ <ك> <All-Lam> ___ <ل> <NS>*<All></p> <p>ه → ه_{Initial2} / ___ ب_{Final3} ___ ب_{Final4}</p> <p>ه → ه_{Initial3} / ___ ج_{Final} ___ <ج> <NS>*<All></p> <p>ه → ه_{Initial5} / ___ ر_{Final2}</p> <p>ه → ه_{Initial6} / ___ س_{Final1} ___ <س> <NS>*<All></p> <p>ه → ه_{Initial7} / ___ س_{Final2}</p> <p>ه → ه_{Initial8} / ___ ص_{Final} ___ <ص> <NS>*<All></p> <p>ه → ه_{Initial9} / ___ ط_{Final} ___ <ط> <NS>*<All> ___ <ل> <Final> ___ <ل> <NS>*<All></p>	<p>ه → ه_{Initial10} / ___ ع_{Final} ___ <ع> <NS>*<All></p> <p>ه → ه_{Initial11} / ___ ف_{Final} ___ <ف> <NS>*<All></p> <p>ه → ه_{Initial12} / ___ </p> <p>ه → ه_{Initial13} / ___ م_{Final1} ___ <م> <NS>*<All></p> <p>ه → ه_{Initial14} / ___ ن_{Final}</p> <p>ه → ه_{Initial15} / ___ ه_{Final1}</p> <p>ه → ه_{Initial16} / ___ ه_{Final} ___ <ه> <NS>*<All> ___ <ه> <NS>*<All></p> <p>ه → ه_{Initial17} / ___ ی_{Final2}</p> <p>ه → ه_{Initial18} / ___ ے_{Final1}</p> <p>ه → ه_{Initial39} / ___ م_{Alt-1} <NS>*<All></p>
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4.3 Analysis of Medial Position Characters:

Given below is general grammar for medial characters occurring in ligatures.

4.3.1 Medial Bay

The 'bay' group of letters occurring in medial position have great flexibility in terms of modifying their own shapes as well as the shape of their preceding characters. For this reason analysis of medial bay is taken as an exception. In almost all cases for medial bay (in three character ligatures) the basic ligature comes from the ligature shape of 'bay+bay+any final glyph' (where '+' stands for concatenation). To convert this ligature shape (of bay+bay+final glyph) to say alphabet x+bay+final glyph ligature; only x's head is placed on the ligature bay+bay+final glyph. In other words:

For all j ∈ final glyphs

For all i ∈ initial or medial glyph heads for each character except bay, seen and suad

i+bay+bay+j forms the shape for i+bay+j ligature

For ligature bay+bay+j shapes and grammar is given below.







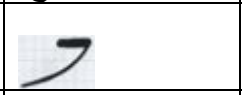
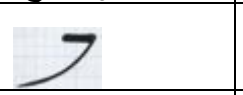
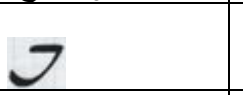






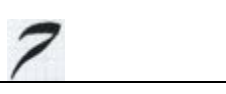

ب _{Medial1}	ب _{Medial2}	ب _{Medial3}	ب _{Medial5}	ب _{Medial7}
ب _{Medial8}	ب _{Medial9}	ب _{Medial10}	ب _{Medial11}	ب _{Medial12}
ب _{Medial13}	ب _{Medial16}	ب _{Medial17}	ب _{Medial18}	ب _{Medial23}
ب _{Medial25}	ب _{Medial33}	ب _{Medial36}	ب _{Medial37}	

<p>ب → ب_{Medial1} / <NS>⁺ ___ <A></p> <p> <NS>⁺ ___ <ك> <All-lam></p> <p> <NS>⁺ ___ <ك> <NS-lam></p> <p style="text-align: right;"><NS>[*] <All></p> <p> <NS>⁺ ___ ل_{Final}</p> <p> <NS>⁺ ___ <ل> <NS>[*] <All></p> <p> <NS>⁺ ___ ب_{Initial2} <NS>[*] <All></p>	<p>ب → ب_{Medial5} / <NS>⁺ ___ ر_{Final2}</p> <p>ب → ب_{Initial6} / <NS>⁺ ___ س_{Final1}</p> <p> <NS>⁺ ___ <س> <NS>[*] <All></p> <p>ب → ب_{Medial7} / <NS>⁺ ___ س_{Final2}</p> <p>ب → ب_{Medial8} / <NS>⁺ ___ ص_{Final}</p> <p> <NS>⁺ ___ <ص> <NS>[*] <All></p>
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<NS>+ ___ ب _{Initial6} <NS>* <All>	ب → ب _{Medial9} / <NS>+ ___ ط _{Final}
<NS>+ ___ ب _{Initial14} <NS>* <All>	<NS>+ ___ <ط> <NS>* <All>
<NS>+ ___ ب _{Medial23}	ب → ب _{Medial10} / <NS>+ ___ ع _{Final}
<NS>+ ___ ب _{Medial25}	<NS>+ ___ <ع> <NS>* <All>
<NS>+ ___ ب _{Medial33}	ب → ب _{Medial11} / <NS>+ ___ ف _{Final}
<NS>+ ___ ب _{Medial36}	<NS>+ ___ <ف> <NS>* <All>
<NS>+ ___ ب _{Medial37}	ب → ب _{Medial12} / <NS>+ ___
ب → ب _{Initial2} / <NS>+ ___ ب _{Medial1} <NS>* <All>	ب → ب _{Medial13} / <NS>+ ___ م _{Final1}
<NS>+ ___ ب _{Medial2} <NS>* <All>	<NS>+ ___ <م> <NS>* <All>
<NS>+ ___ ب _{Medial8} <NS>* <All>	ب → ب _{Initial14} / <NS>+ ___ ن _{Final}
<NS>+ ___ ب _{Medial9} <NS>* <All>	ب → ب _{Initial15} / <NS>+ ___ ه _{Final1}
<NS>+ ___ ب _{Medial10} <NS>* <All>	ب → ب _{Medial16} / <NS>+ ___ ه _{Final}
<NS>+ ___ ب _{Medial12} <NS>* <All>	<NS>+ ___ <ه> <NS>* <All>
<NS>+ ___ ب _{Initial15} <NS>* <All>	<NS>+ ___ <ه> <NS>* <All>
<NS>+ ___ ب _{Medial16} <NS>* <All>	ب → ب _{Medial17} / <NS>+ ___ ع _{Final2}
<NS>+ ___ ب _{Medial18} <NS>* <All>	ب → ب _{Medial18} / <NS>+ ___ ع _{Final1}
ب → ب _{Medial2} / <NS>+ ___ ب _{Final1}	ب → ب _{Medial23} / <NS>+ ___ ب _{Medial3}
<NS>+ ___ ب _{Final2}	ب → ب _{Medial25} / <NS>+ ___ ب _{Medial5}
ب → ب _{Medial3} / <NS>+ ___ ج _{Final}	ب → ب _{Medial33} / <NS>+ ___ ب _{Medial13}
<NS>+ ___ <ج> <NS>* <All>	ب → ب _{Medial36} / <NS>+ ___ ب _{Medial16}
	ب → ب _{Medial37} / <NS>+ ___ ب _{Medial17}

4.3.2 Medial Jeem

Given below is analysis of 17 medial shapes of letter 'Jeem'.

				
ج _{Medial 1}	ج _{Medial2}	ج _{Medial3}	ج _{Medial5}	ج _{Medial6}
				
ج _{Medial 7}	ج _{Medial8}	ج _{Medial 9}	ج _{Medial10}	ج _{Medial11}
				
ج _{Medial12}	ج _{Medial13}	ج _{Medial14}	ج _{Medial15}	ج _{Medial16}
				
ج _{Medial17}	ج _{Medial18}			

<p>ج → ج Medial1 / <NS>+ ___ <A> <NS>+ ___ <ك><All-lam> <NS>+ ___ <ك><NS-lam> <NS>*<All> <NS>+ ___ <ل> <NS>*<All></p> <p>ج → ج Medial2 / <NS>+ ___ ب Final1 <NS>+ ___ ب Final2</p> <p>ج → ج Medial3 / <NS>+ ___ ج Final <NS>+ ___ <ج><NS>*<All></p> <p>ج → ج Medial5 / <NS>+ ___ ر Final2</p> <p>ج → ج Medial6 / <NS>+ ___ س Final1 <NS>+ ___ <س><NS>*<All></p> <p>ج → ج Medial7 / <NS>+ ___ س Final2</p> <p>ج → ج Medial8 / <NS>+ ___ ص Final <NS>+ ___ <ص><NS>*<All></p> <p>ج → ج Medial9 / <NS>+ ___ ط Final <NS>+ ___ <ط><NS>*<All> <NS>+ ___ <ك>ل Final <NS>+ ___ <ك><ل> <NS>*<All></p>	<p>ج → ج Medial10 / <NS>+ ___ ع Final <NS>+ ___ <ع><NS>*<All></p> <p>ج → ج Medial11 / <NS>+ ___ ف Final <NS>+ ___ <ف><NS>*<All></p> <p>ج → ج Medial12 / <NS>+ ___ </p> <p>ج → ج Medial13 / <NS>+ ___ م Final1 <NS>+ ___ <م><NS>*<All></p> <p>ج → ج Medial14 / <NS>+ ___ ن Final</p> <p>ج → ج Medial15 / <NS>+ ___ ه Final1</p> <p>ج → ج Medial16 / <NS>+ ___ ه Final <NS>+ ___ <ه><NS>*<All> <NS>+ ___ <ه><NS>*<All></p> <p>ج → ج Medial17 / <NS>+ ___ ی Final2</p> <p>ج → ج Medial18 / <NS>+ ___ ے Final1</p>
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4.3.3 Medial Seen

Given below is analysis of 17 medial shapes of letter 'Seen'.




س Medial1	س Medial2	س Medial3	س Medial5	س Medial6
س Medial7	س Medial8	س Medial9	س Medial10	س Medial11
س Medial12	س Medial13	س Medial14	س Medial15	س Medial16
س Medial17-1	س Medial17-2	س Medial18	س Medial21	

<p>س → س Medial1 / <NS>+ __ <A> <NS>+ __ <ك><All-lam> <NS>+ __ <ك><NS-lam> <NS>*<All> <NS>+ __ <ل> <NS>*<All> <NS>+ __ ل Final <NS>+ __ ب₂ <NS>*<All> <NS>+ __ ب₆ <NS>*<All> <NS>+ __ ب₁₄ <NS>*<All> <NS>+ __ ب Medial2 <NS>*<All> <NS>+ __ ب Medial8 <NS>*<All> <NS>+ __ ب Medial9 <NS>*<All> <NS>+ __ ب Medial10 <NS>*<All> <NS>+ __ ب Medial12 <NS>*<All> <NS>+ __ ب Medial23 <NS>+ __ ب Medial25 <NS>+ __ ب Medial33 <NS>+ __ ب Medial36 <NS>+ __ ب Medial37</p>	<p>س → س Medial10 / <NS>+ __ ع Final <NS>+ __ <ع><NS>*<All> س → س Medial11 / <NS>+ __ ف Final <NS>+ __ <ف><NS>*<All></p> <p>س → س Medial12 / <NS>+ __ س → س Medial13 / <NS>+ __ م Final1 <NS>+ __ <م><NS>*<All> س → س Medial14 / <NS>+ __ ن Final س → س Medial15 / <NS>+ __ ه Final1 س → س Medial16 / <NS>+ __ ه Final <NS>+ __ <ه><NS>*<All> <NS>+ __ <ه><NS>*<All> س → س Medial17 / <NS>+ __ ی Final2 س → س Medial18 / <NS>+ __ ے Final1 س → س Medial21 / <NS>+ __ ب Medial1 <NS>*<All> <NS>+ __ ب₁₅ <NS>*<All> <NS>+ __ ب Medial16 <NS>*<All> <NS>+ __ ب Medial18 <NS>*<All></p>
<p>س → س Medial2 / <NS>+ __ ب Final1 <NS>+ __ ب Final2 س → س Medial3 / <NS>+ __ ج Final <NS>+ __ <ج><NS>*<All> س → س Medial5 / <NS>+ __ ر Final2 س → س Medial6 / <NS>+ __ س Final1 <NS>+ __ <س><NS>*<All> س → س Medial7 / <NS>+ __ س Final2 س → س Medial8 / <NS>+ __ ص Final <NS>+ __ <ص><NS>*<All> س → س Medial9 / <NS>+ __ ط Final <NS>+ __ <ط><NS>*<All> <NS>+ __ ل <ك> Final <NS>+ __ <ك><ل> <NS>*<All></p>	

4.3.4 Medial Suad

Given below is analysis of 17 medial shapes of letter 'Suad'. These shapes are same as initial shapes of suad. Their grammar with respect to medial position is given below.






<p>ص → ص^{Initial1} / <NS>⁺ ___ <A> <NS>⁺ ___ <ك> <All-lam> <NS>⁺ ___ <ك> <NS-lam> <NS>[*] <All> <NS>⁺ ___ <ل> <NS>[*] <All> <NS>⁺ ___ ل^{Final} <NS>⁺ ___ ب₂ <NS>[*] <All> <NS>⁺ ___ ب₆ <NS>[*] <All> <NS>⁺ ___ ب₁₄ <NS>[*] <All> <NS>⁺ ___ ب^{Medial2} <NS>[*] <All> <NS>⁺ ___ ب^{Medial8} <NS>[*] <All> <NS>⁺ ___ ب^{Medial9} <NS>[*] <All> <NS>⁺ ___ ب^{Medial10} <NS>[*] <All> <NS>⁺ ___ ب^{Medial12} <NS>[*] <All> <NS>⁺ ___ ب^{Medial23} <NS>⁺ ___ ب^{Medial25} <NS>⁺ ___ ب^{Medial33} <NS>⁺ ___ ب^{Medial36} <NS>⁺ ___ ب^{Medial37} ص → ص^{Initial2} / <NS>⁺ ___ ب^{Final1} <NS>⁺ ___ ب^{Final2} ص → ص^{Initial3} / <NS>⁺ ___ ج^{Final} <NS>⁺ ___ <ج> <NS>[*] <All> ص → ص^{Initial5} / <NS>⁺ ___ ر^{Final2} ص → ص^{Initial6} / <NS>⁺ ___ س^{Final1} <NS>⁺ ___ <س> <NS>[*] <All> ص → ص^{Initial7} / <NS>⁺ ___ س^{Final2} ص → ص^{Initial8} / <NS>⁺ ___ ص^{Final} <NS>⁺ ___ <ص> <NS>[*] <All> ص → ص^{Initial9} / <NS>⁺ ___ ط^{Final} <NS>⁺ ___ <ط> <NS>[*] <All> <NS>⁺ ___ ل^{Final} <ك> <NS>⁺ ___ <ك> <ل> <NS>[*] <All></p>	<p>ص → ص^{Initial10} / <NS>⁺ ___ ع^{Final} <NS>⁺ ___ <ع> <NS>[*] <All> ص → ص^{Initial11} / <NS>⁺ ___ ف^{Final} <NS>⁺ ___ <ف> <NS>[*] <All> ص → ص^{Initial12} / <NS>⁺ ___ ص → ص^{Initial13} / <NS>⁺ ___ م^{Final1} <NS>⁺ ___ <م> <NS>[*] <All> ص → ص^{Initial14} / <NS>⁺ ___ ن^{Final} ص → ص^{Initial15} / <NS>⁺ ___ ه^{Final1} ص → ص^{Initial16} / <NS>⁺ ___ ه^{Final} <NS>⁺ ___ <ه> <NS>[*] <All> <NS>⁺ ___ <ه> <NS>[*] <All> ص → ص^{Initial17} / <NS>⁺ ___ ی^{Final2} ص → ص^{Initial18} / <NS>⁺ ___ ے^{Final1} ص → ص^{Initial21} / <NS>⁺ ___ ب^{Medial1} <NS>[*] <All> <NS>⁺ ___ ب₁₅ <NS>[*] <All> <NS>⁺ ___ ب^{Medial16} <NS>[*] <All> <NS>⁺ ___ ب^{Medial18} <NS>[*] <All></p>
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ع _{Medial11}	ع _{Medial12}	ع _{Medial13}	ع _{Medial14}	ع _{Medial15}
				
ع _{Medial16}	ع _{Medial17}	ع _{Medial18}		

<p>ع→ع_{Medial1} / <NS>⁺ __ <A> <NS>⁺ __ <ك><All-lam> <NS>⁺ __ <ك><NS-lam> <NS>* <All> <NS>⁺ __ <ل><NS>* <All></p> <p>ع→ع_{Medial2} / <NS>⁺ __ ب_{Final1} <NS>⁺ __ ب_{Final2}</p> <p>ع→ع_{Medial3} / <NS>⁺ __ ج_{Final} <NS>⁺ __ <ج><NS>* <All></p> <p>ع→ع_{Medial5} / <NS>⁺ __ ر_{Final2}</p> <p>ع→ع_{Medial6} / <NS>⁺ __ س_{Final1} <NS>⁺ __ <س><NS>* <All></p> <p>ع→ع_{Medial7} / <NS>⁺ __ س_{Final2}</p> <p>ع→ع_{Medial8} / <NS>⁺ __ ص_{Final} <NS>⁺ __ <ص><NS>* <All></p> <p>ع→ع_{Medial9} / <NS>⁺ __ ط_{Final} <NS>⁺ __ <ط><NS>* <All> <NS>⁺ __ <ك> ل_{Final} <NS>⁺ __ <ك><ل><NS>* <All></p>	<p>ع→ع_{Medial10} / <NS>⁺ __ ع_{Final} <NS>⁺ __ <ع><NS>* <All></p> <p>ع→ع_{Medial11} / <NS>⁺ __ ف_{Final} <NS>⁺ __ <ف><NS>* <All></p> <p>ع→ع_{Medial12} / <NS>⁺ __ </p> <p>ع→ع_{Medial13} / <NS>⁺ __ م_{Final1} <NS>⁺ __ <م><NS>* <All></p> <p>ع→ع_{Medial14} / <NS>⁺ __ ن_{Final}</p> <p>ع→ع_{Medial15} / <NS>⁺ __ ه_{Final1}</p> <p>ع→ع_{Medial16} / <NS>⁺ __ ه_{Final} <NS>⁺ __ <ه><NS>* <All> <NS>⁺ __ <ه><NS>* <All></p> <p>ع→ع_{Medial17} / <NS>⁺ __ ي_{Final2}</p> <p>ع→ع_{Medial18} / <NS>⁺ __ ع_{Final1}</p>
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4.3.7 Medial Fay

Given below is analysis of 17 medial shapes of letter ‘Fay’. Letter ‘Qaf’ in medial position has same shape as letter ‘Fay’.

				
ف _{Medial1}	ف _{Medial2}	ف _{Medial3}	ف _{Medial5}	ف _{Medial6}

				
ف _{Medial7}	ف _{Medial8}	ف _{Medial9}	ف _{Medial10}	ف _{Medial11}
				
ف _{Medial12}	ف _{Medial13}	ف _{Medial14}	ف _{Medial15}	ف _{Medial16}
				
ف _{Medial17}	ف _{Medial18}			

<p>ف→ف_{Medial1} / <NS>⁺ __ <A> <NS>⁺ __ <ك><All-lam> <NS>⁺ __ <ك><NS-lam> <NS>[*]<All> <NS>⁺ __ <ل><NS>[*]<All></p> <p>ف→ف_{Medial2} / <NS>⁺ __ ب_{Final1} <NS>⁺ __ ب_{Final2}</p> <p>ف→ف_{Medial3} / <NS>⁺ __ ج_{Final} <NS>⁺ __ <ج><NS>[*]<All></p> <p>ف→ف_{Medial5} / <NS>⁺ __ ر_{Final2}</p> <p>ف→ف_{Medial6} / <NS>⁺ __ س_{Final1} <NS>⁺ __ <س><NS>[*]<All></p> <p>ف→ف_{Medial7} / <NS>⁺ __ س_{Final2}</p> <p>ف→ف_{Medial8} / <NS>⁺ __ ص_{Final} <NS>⁺ __ <ص><NS>[*]<All></p> <p>ف→ف_{Medial9} / <NS>⁺ __ ط_{Final} <NS>⁺ __ <ط><NS>[*]<All> <NS>⁺ __ <ك>_{Final} <NS>⁺ __ <ك><ل><NS>[*]<All></p>	<p>ف→ف_{Medial10} / <NS>⁺ __ ع_{Final} <NS>⁺ __ <ع><NS>[*]<All></p> <p>ف→ف_{Medial11} / <NS>⁺ __ ف_{Final} <NS>⁺ __ <ف><NS>[*]<All></p> <p>ف→ف_{Medial12} / <NS>⁺ __ </p> <p>ف→ف_{Medial13} / <NS>⁺ __ م_{Final1} <NS>⁺ __ <م><NS>[*]<All></p> <p>ف→ف_{Medial14} / <NS>⁺ __ ن_{Final}</p> <p>ف→ف_{Medial15} / <NS>⁺ __ ه_{Final1}</p> <p>ف→ف_{Medial16} / <NS>⁺ __ ه_{Final} <NS>⁺ __ <ه><NS>[*]<All> <NS>⁺ __ <ه><NS>[*]<All></p> <p>ف→ف_{Medial17} / <NS>⁺ __ ی_{Final2}</p> <p>ف→ف_{Medial18} / <NS>⁺ __ ے_{Final1}</p>
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4.3.8 Medial Kaf

Given below is analysis of 17 medial shapes of letter 'Kaf'. Kaf undertakes a rounded form when it is followed by a <class A> letter.



















ک Medial 1-1	ک Medial 2-1-1	ک Medial 2-1-2	ک Medial 3-1	ک Medial 4-1	
ک Medial 6-1	ک Medial 7-1	ک Medial 8-1	ک Medial 9-1	ک Medial 10-1	
ک Medial 11-1	ک Medial 12-1	ک Medial 13-1	ک Medial 14-1	ک Medial 15-1	
ک Medial 16-1 [ک13]	ک Medial 17-1	ک Medial 18-1	ک Medial 19-1		

<p>ک → ک_{Medial11-1} / <NS>⁺ ___ Final</p> <p> <NS>⁺ ___ ل Final</p> <p> <NS>⁺ ___ لا Final</p> <p> <NS>⁺ ___ <ل> <NS>[*] <All></p> <p>ک → ک_{Medial2-1} / <NS>⁺ ___ ب Final1</p> <p> <NS>⁺ ___ ب Final2</p> <p>ک → ک_{Medial3-1} / <NS>⁺ ___ ج Final</p> <p> <NS>⁺ ___ <ج> <NS>[*] <All></p> <p>ک → ک_{Medial5-1} / <NS>⁺ ___ ر Final1</p> <p>ک → ک_{Medial6-1} / <NS>⁺ ___ س Final1</p> <p> <NS>⁺ ___ <س> <NS>[*] <All></p> <p>ک → ک_{Medial7-1} / <NS>⁺ ___ س Final2</p> <p>ک → ک_{Medial8-1} / <NS>⁺ ___ ص Final</p> <p> <NS>⁺ ___ <ص> <NS>[*] <All></p>	<p>ک → ک_{Medial10-1} / <NS>⁺ ___ ع Final</p> <p> <NS>⁺ ___ <ع> <NS>[*] <All></p> <p>ک → ک_{Medial11-1} / <NS>⁺ ___ ف Final</p> <p> <NS>⁺ ___ <ف> <NS>[*] <All></p> <p>ک → ک_{Medial12-1} / <NS>⁺ ___ </p> <p>ک → ک_{Medial13-1} / <NS>⁺ ___ م Final1</p> <p> <NS>⁺ ___ <م> <NS>[*] <All></p> <p>ک → ک_{Medial14-1} / <NS>⁺ ___ ن Final</p> <p>ک → ک_{Medial15-1} / <NS>⁺ ___ ه Final1</p> <p>ک → ک_{Medial16-1} / <NS>⁺ ___ ه Final</p> <p> <NS>⁺ ___ <ه> <NS>[*] <All></p> <p> <NS>⁺ ___ <ه> <NS>[*] <All></p> <p>ک → ک_{Medial17-1} / <NS>⁺ ___ ی Final1</p>
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<p>ک → ک_{Medial9-1} / <NS>⁺ ط_{Final}</p> <p> <NS>⁺ <ط><NS>[*]<All></p> <p> <NS>⁺ <ک> ل_{Final}</p> <p> <NS>⁺ <ک><ل><NS>[*]<All></p>	<p>ک → ک_{Medial18-1} / <NS>⁺ ے_{Final1}</p> <p>ک → ک_{Medial19-1} / <NS>⁺ <Ashort></p> <p> <NS>⁺ د_{Final}</p> <p> <NS>⁺ <ک><All-lam></p> <p> <NS>⁺ <ک><NS-lam> <NS>[*]<All></p>
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4.3.9 Medial Lam

Given below is analysis of 19 medial shapes of letter 'Lam'.

					
ل _{Medial2-1}	ل _{Medial2-2}	ل _{Medial3}	ل _{Medial4}	ل _{Medial6}	ل _{Medial7}
					
ل _{Medial8}	ل _{Medial9}	ل _{Medial10}	ل _{Medial11}	ل _{Medial12 [6]}	ل _{Medial13}
					
ل _{Medial14}	ل _{Medial15}	ل _{Medial16}	ل _{Medial17}	ل _{Medial18}	ل _{Medial19}

<p>ل + ا_{Final} → لا / <NS>⁺ ___</p> <p>ل → ل_{Medial2} / <NS>⁺ ب_{Final1}</p> <p> <NS>⁺ ب_{Final2}</p> <p>ل → ل_{Medial3} / <NS>⁺ ج_{Final}</p> <p> <NS>⁺ <ج><NS>[*]<All></p> <p>ل → ل_{Medial4} / <NS>⁺ ر_{Final1}</p> <p>ل → ل_{Medial6} / <NS>⁺ س_{Final1}</p> <p> <NS>⁺ <س><NS>[*]<All></p> <p>ل → ل_{Medial7} / <NS>⁺ س_{Final2}</p> <p>ل → ل_{Medial8} / <NS>⁺ ص_{Final}</p> <p> <NS>⁺ <ص><NS>[*]<All></p> <p>ل → ل_{Medial9} / <NS>⁺ ط_{Final}</p> <p> <NS>⁺ <ط><NS>[*]<All></p> <p> <NS>⁺ <ک> ل_{Final}</p> <p> <NS>⁺ <ک><ل><NS>[*]<All></p>	<p>ل → ل_{Medial10} / <NS>⁺ ع_{Final}</p> <p> <NS>⁺ <ع><NS>[*]<All></p> <p>ل → ل_{Medial11} / <NS>⁺ ف_{Final}</p> <p> <NS>⁺ <ف><NS>[*]<All></p> <p>ل → ل_{Medial12} / <NS>⁺ </p> <p>ل → ل_{Medial13} / <NS>⁺ م_{Final1}</p> <p> <NS>⁺ <م><NS>[*]<All></p> <p>ل → ل_{Medial14} / <NS>⁺ ن_{Final}</p> <p>ل → ل_{Medial15} / <NS>⁺ ه_{Final1}</p> <p>ل → ل_{Medial16} / <NS>⁺ ه_{Final}</p> <p> <NS>⁺ <ه><NS>[*]<All></p> <p> <NS>⁺ <ه><NS>[*]<All></p> <p>ل → ل_{Medial17} / <NS>⁺ ی_{Final1}</p> <p>ل → ل_{Medial18} / <NS>⁺ ے_{Final1}</p> <p>ل → ل_{Medial19} / <NS>⁺ د_{Final}</p>
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	<NS>+ ___ ک _{Final1} <NS>+ ___ ک _{Final2} <NS>+ ___ ل _{Final} <NS>+ ___ لا _{Final} <NS>+ ___ <ک><All-lam> <NS>+ ___ <ک><NS-lam> <NS>*<All> <NS>+ ___ <ل><NS>*<All>
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4.3.10 Medial Meem

Given below is analysis of 17 medial shapes of letter 'Meem'.

م Medial1	م Medial2	م Medial3	م Medial 5	م Medial6
م Medial7	م Medial8	م Medial9	م Medial10	م Medial11
م Medial12	م Medial13	م Medial14	م Medial15	م Medial16 [م 13]
م Medial17	م Medial18			

م Medial1 / <NS>+ ___ <A> <NS>+ ___ <ک><All-lam> <NS>+ ___ <ک><NS-lam><NS>*<All> <NS>+ ___ <ل><NS>*<All>	م Medial10 / <NS>+ ___ ع _{Final} <NS>+ ___ <ع><NS>*<All>
م Medial2 / <NS>+ ___ ب _{Final1} <NS>+ ___ ب _{Final2}	م Medial11 / <NS>+ ___ ف _{Final} <NS>+ ___ <ف><NS>*<All>
م Medial3 / <NS>+ ___ ج _{Final} <NS>+ ___ <ج><NS>*<All>	م Medial12 / <NS>+ ___
م Medial5 / <NS>+ ___ ر _{Final2}	م Medial13 / <NS>+ ___ م _{Final1} <NS>+ ___ <م><NS>*<All>
م Medial6 / <NS>+ ___ س _{Final1} <NS>+ ___ <س><NS>*<All>	م Medial14 / <NS>+ ___ ن _{Final}
م Medial7 / <NS>+ ___ س _{Final2}	م Medial15 / <NS>+ ___ ه _{Final1}
	م Medial16 / <NS>+ ___ ه _{Final} <NS>+ ___ <ه><NS>*<All>

<p> $\text{م} \rightarrow \text{م}^{\text{Medial8}} / \langle \text{NS} \rangle^+ \text{ص}^{\text{Final}}$ $\langle \text{NS} \rangle^+ \text{ص} \langle \text{NS} \rangle^* \langle \text{All} \rangle$ </p> <p> $\text{م} \rightarrow \text{م}^{\text{Medial9}} / \langle \text{NS} \rangle^+ \text{ط}^{\text{Final}}$ $\langle \text{NS} \rangle^+ \text{ط} \langle \text{NS} \rangle^* \langle \text{All} \rangle$ $\langle \text{NS} \rangle^+ \text{ك}^{\text{Final}}$ $\langle \text{NS} \rangle^+ \text{ك} \langle \text{ل} \rangle \langle \text{NS} \rangle^* \langle \text{All} \rangle$ </p>	<p> $\langle \text{NS} \rangle^+ \text{ه} \langle \text{NS} \rangle^* \langle \text{All} \rangle$ </p> <p> $\text{م} \rightarrow \text{م}^{\text{Medial17}} / \langle \text{NS} \rangle^+ \text{ى}^{\text{Final2}}$ </p> <p> $\text{م} \rightarrow \text{م}^{\text{Medial18}} / \langle \text{NS} \rangle^+ \text{ے}^{\text{Final1}}$ </p>
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4.3.11 Medial Goal Hay

Given below is analysis of 17 medial shapes of letter 'Goal Hay'.

◊Medial1	◊Medial2	◊Medial3	◊Medial 5	◊Medial6
◊Medial7	◊Medial8	◊Medial9	◊Medial10	◊Medial11
◊Medial12	◊Medial13	◊Medial14	◊Medial15	◊Medial16[◊13]
◊Medial17	◊Medial18			

<p> $\text{ه} \rightarrow \text{ه}^{\text{Medial1}} / \langle \text{NS} \rangle^+ \text{ا}^{\text{Final}}$ $\langle \text{NS} \rangle^+ \text{ك} \langle \text{All-lam} \rangle$ $\langle \text{NS} \rangle^+ \text{ك} \langle \text{NS-lam} \rangle$ $\langle \text{NS} \rangle^* \langle \text{All} \rangle$ $\langle \text{NS} \rangle^+ \text{ل} \langle \text{NS} \rangle^* \langle \text{All} \rangle$ </p> <p> $\text{ه} \rightarrow \text{ه}^{\text{Medial2}} / \langle \text{NS} \rangle^+ \text{ب}^{\text{Final1}}$ $\langle \text{NS} \rangle^+ \text{ب}^{\text{Final2}}$ </p> <p> $\text{ه} \rightarrow \text{ه}^{\text{Medial3}} / \langle \text{NS} \rangle^+ \text{ج}^{\text{Final}}$ $\langle \text{NS} \rangle^+ \text{ج} \langle \text{NS} \rangle^* \langle \text{All} \rangle$ </p> <p> $\text{ه} \rightarrow \text{ه}^{\text{Medial5}} / \langle \text{NS} \rangle^+ \text{ر}^{\text{Final2}}$ </p> <p> $\text{ه} \rightarrow \text{ه}^{\text{Medial6}} / \langle \text{NS} \rangle^+ \text{س}^{\text{Final1}}$ $\langle \text{NS} \rangle^+ \text{س} \langle \text{NS} \rangle^* \langle \text{All} \rangle$ </p> <p> $\text{ه} \rightarrow \text{ه}^{\text{Medial7}} / \langle \text{NS} \rangle^+ \text{س}^{\text{Final2}}$ </p> <p> $\text{ه} \rightarrow \text{ه}^{\text{Medial8}} / \langle \text{NS} \rangle^+ \text{ص}^{\text{Final}}$ </p>	<p> $\text{ه} \rightarrow \text{ه}^{\text{Medial10}} / \langle \text{NS} \rangle^+ \text{ع}^{\text{Final}}$ $\langle \text{NS} \rangle^+ \text{ع} \langle \text{NS} \rangle^* \langle \text{All} \rangle$ </p> <p> $\text{ه} \rightarrow \text{ه}^{\text{Medial11}} / \langle \text{NS} \rangle^+ \text{ف}^{\text{Final}}$ $\langle \text{NS} \rangle^+ \text{ف} \langle \text{NS} \rangle^* \langle \text{All} \rangle$ </p> <p> $\text{ه} \rightarrow \text{ه}^{\text{Medial12}} / \langle \text{NS} \rangle^+ \text{ب}^{\text{Final}}$ </p> <p> $\text{ه} \rightarrow \text{ه}^{\text{Medial13}} / \langle \text{NS} \rangle^+ \text{م}^{\text{Final1}}$ $\langle \text{NS} \rangle^+ \text{م} \langle \text{NS} \rangle^* \langle \text{All} \rangle$ </p> <p> $\text{ه} \rightarrow \text{ه}^{\text{Medial14}} / \langle \text{NS} \rangle^+ \text{ن}^{\text{Final}}$ </p> <p> $\text{ه} \rightarrow \text{ه}^{\text{Medial15}} / \langle \text{NS} \rangle^+ \text{ه}^{\text{Final1}}$ </p> <p> $\text{ه} \rightarrow \text{ه}^{\text{Medial16}} / \langle \text{NS} \rangle^+ \text{ه}^{\text{Final}}$ $\langle \text{NS} \rangle^+ \text{ه} \langle \text{NS} \rangle^* \langle \text{All} \rangle$ $\langle \text{NS} \rangle^+ \text{ه} \langle \text{NS} \rangle^* \langle \text{All} \rangle$ </p> <p> $\text{ه} \rightarrow \text{ه}^{\text{Medial17}} / \langle \text{NS} \rangle^+ \text{ى}^{\text{Final2}}$ </p>
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<p> <NS>+ __ <ص><NS>* <All> ھ→ھ Medial9 / <NS>+ __ ط Final <NS>+ __ <ط><NS>* <All> <NS>+ __ <ك>ل Final <NS>+ __ <ك><ل><NS>* <All></p>	<p>ھ→ھ Medial18 / <NS>+ __ ے Final1</p>
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4.3.12 Medial Do Chashmi Hay

Given below is analysis of 17 medial shapes of letter 'Do Chashmi Hay'.

ھ Medial1	ھ Medial2	ھ Medial3	ھ Medial 5	ھ Medial6
ھ Medial7	ھ Medial8	ھ Medial9	ھ Medial10	ھ Medial11
ھ Medial12	ھ Medial13	ھ Medial14	ھ Medial15	ھ Medial16[ھ13]
ھ Medial17	ھ Medial18			









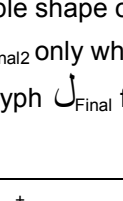
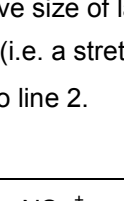
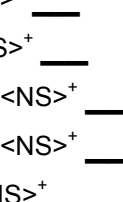
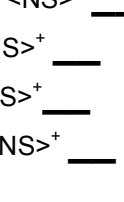
<p>ھ→ھ Medial1 / <NS>+ __ <A> <NS>+ __ <ك><All-lam> <NS>+ __ <ك><NS-lam> <NS>* <All> <NS>+ __ <ل><NS>* <All> ھ→ھ Medial2 / <NS>+ __ ب Final1 <NS>+ __ ب Final2 ھ→ھ Medial3 / <NS>+ __ ج Final <NS>+ __ <ج><NS>* <All> ھ→ھ Medial5 / <NS>+ __ ر Final2 ھ→ھ Medial6 / <NS>+ __ س Final1 <NS>+ __ <س><NS>* <All> ھ→ھ Medial7 / <NS>+ __ س Final2 ھ→ھ Medial8 / <NS>+ __ ص Final <NS>+ __ <ص><NS>* <All></p>	<p>ھ→ھ Medial10 / <NS>+ __ ع Final <NS>+ __ <ع><NS>* <All> ھ→ھ Medial11 / <NS>+ __ ف Final <NS>+ __ <ف><NS>* <All> ھ→ھ Medial12 / <NS>+ __ ھ→ھ Medial13 / <NS>+ __ م Final1 <NS>+ __ <م><NS>* <All> ھ→ھ Medial14 / <NS>+ __ ن Final ھ→ھ Medial15 / <NS>+ __ ھ Final1 ھ→ھ Medial16 / <NS>+ __ ھ Final <NS>+ __ <ھ><NS>* <All> <NS>+ __ <ھ><NS>* <All> ھ→ھ Medial17 / <NS>+ __ ی Final2 ھ→ھ Medial18 / <NS>+ __ ے Final1</p>
---	---

<p> $\text{ه} \rightarrow \text{ه}$ Medial9 / $\langle \text{NS} \rangle^+ \underline{\quad} \text{ط}$ Final $\langle \text{NS} \rangle^+ \underline{\quad} \langle \text{ط} \rangle \langle \text{NS} \rangle^* \langle \text{All} \rangle$ $\langle \text{NS} \rangle^+ \underline{\quad} \langle \text{ك} \rangle \text{ل}$ Final $\langle \text{NS} \rangle^+ \underline{\quad} \langle \text{ك} \rangle \langle \text{ل} \rangle \langle \text{NS} \rangle^* \langle \text{All} \rangle$ </p>	
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4.4 Analysis of Final Position Characters:

In this section shapes and context sensitive grammar for final shapes of characters is given. This grammar indicates all possible final shapes that exist in Nastalique and the context in which they occur.

1	ا _{Final}		2	ب _{Final1}	
3	ب _{Final2}		4	ب _{Final3}	
5	ب _{Final4}		6	ج _{Final}	
7	د _{Final}		8	ر _{Final1}	
9	ر _{Final2}		10	س _{Final1}	
11	س _{Final2}		12	ص _{Final}	
13	ط _{Final}		14	ع _{Final}	
15	ف _{Final}		16	ق _{Final}	
17	ک _{Final1}		18	ک _{Final2}	

19	ل _{Final}		20	م _{Final1}	
21	م _{Final2}		22	ن _{Final}	
23	و _{Final}		24	ه _{Final1}	
25	ه _{Final2}		26	ه _{Final}	
27	ی _{Final1}		28	ی _{Final2}	
29	ا _{Final1}		30	لا _{Final}	



















In the above table shape of ه_{Final1} and ه_{Final2} are same but relative size of latter is greater. Also, shape م → م_{Final2} only when preceding character is a 'Kashida' (i.e. a stretched glyph). It should be noted that glyph ل_{Final} forces preceding characters to move to line 2.

ا → ا _{Final} / <NS> ⁺ ___	ص → ص _{Final} / <NS> ⁺ ___
د → د _{Final} / <NS> ⁺ ___	ط → ط _{Final} / <NS> ⁺ ___
ک → ک _{Final1} / <NS> ⁺ ___	ع → ع _{Final} / <NS> ⁺ ___
ک → ک _{Final2} / <NS> ⁺ ___	ف → ف _{Final} / <NS> ⁺ ___
ل → ل _{Final} / <NS> ⁺ ___	ق → ق _{Final} / <NS> ⁺ ___
لا → لا _{Final} / <NS> ⁺ ___	و → و _{Final} / <NS> ⁺ ___
ب → ب _{Final1} / <NS> ⁺ ___	م → م _{Final1} / <NS> ⁺ ___
ب → ب _{Final2} / <NS> ⁺ ___	م → م _{Final2} / <Kashish> ___
ب → ب _{Final3} / <NS> ⁺ ___	ن → ن _{Final} / <NS> ⁺ ___
ب → ب _{Final4} / <NS> ⁺ ___	ه → ه _{Final1} / <Char Before GoalHay1> ___
ج → ج _{Final} / <NS> ⁺ ___	ه → ه _{Final2} / <Char Before GoalHay2> ___
ر → ر _{Final1} / <Char Before Ray1> ___	ه → ه _{Final} / <NS> ⁺ ___

ر → ر _{Final2} / <Char Before Ray2> ____	ی → ی _{Final1} / <Char Before ChotiYeh1> ____
س → س _{Final1} / <NS> ⁺ ____	ی → ی _{Final2} / <Char Before ChotiYeh2> ____
س → س _{Final2} / <NS> ⁺ ____	ے → ے _{Final1} / <NS> ⁺ ____

4.5 Analysis of Alternative Glyphs:

















4.5.1 Alternative Initial Kaf

				
ک ₁₋₁	ک ₂₋₂₋₁	ک ₂₋₂₋₂	ک ₃₋₂	ک ₄₋₂
				
ک ₆₋₂	ک ₇₋₂	ک ₈₋₂	ک ₉₋₂	ک ₁₀₋₂
				
ک ₁₁₋₂	ک ₁₂₋₂	ک ₁₃₋₂	ک ₁₄₋₂	ک ₁₅₋₂
				
ک ₁₆₋₂	ک ₁₇₋₂	ک ₁₈₋₂	ک ₁₉₋₂	ک ₂₀₋₁

<p>ک → ک_{Initial1-2} / ___ Final ___ لا_{Final} ___ <ل> <NS>* <All></p> <p>ک → ک_{Initial2-2} / ___ ب_{Final3} ___ ب_{Final4}</p> <p>ک → ک_{Initial3-2} / ___ ج_{Final} ___ <ج> <NS>* <All></p> <p>ک → ک_{Initial5-2} / ___ ر_{Final1}</p> <p>ک → ک_{Initial6-2} / ___ س_{Final1} ___ <س> <NS>* <All></p> <p>ک → ک_{Initial7-2} / ___ س_{Final2}</p> <p>ک → ک_{Initial8-2} / ___ ص_{Final} ___ <ص> <NS>* <All></p> <p>ک → ک_{Initial9-2} / ___ ط_{Final} ___ <ط> <NS>* <All> ___ ل_{Final} <ک> ___ ل <NS>* <All></p>	<p>ک → ک_{Initial12-2} / ___ </p> <p>ک → ک_{Initial13-2} / ___ م_{Final1} ___ <م> <NS>* <All></p> <p>ک → ک_{Initial 14-2} / ___ ن_{Final}</p> <p>ک → ک_{Initial15-2} / ___ ه_{Final1}</p> <p>ک → ک_{Initial16-2} / ___ ه_{Final} ___ <ه> <NS>* <All> ___ <ه> <NS>* <All></p> <p>ک → ک_{Initial17-2} / ___ ی_{Final1}</p> <p>ک → ک_{Initial18-2} / ___ ے_{Final1}</p> <p>ک → ک_{Initial19-2} / ___ <Ashort> ___ <ک> <NS-Lam> <NS>* <All> ___ <ک> <All-Lam> ___ د_{Final}</p> <p>ک → ک_{Initial20-1} / ___ ل_{Final}</p>
--	---

<p>ک → ک_{Initial10-2} / ___ ع_{Final} ___ <ع><NS>*<All></p> <p>ک → ک_{Initial11-2} / ___ ف_{Final} ___ <ف><NS>*<All></p>	
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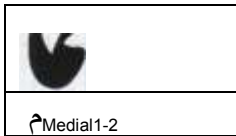
4.5.2 Alternative Medial Kaf

				
ک _{Medial 1-2}	ک _{Medial 2-2-1}	ک _{Medial 2-2-2}	ک _{Medial 3-2}	ک _{Medial 4-2}
				
ک _{Medial 6-2}	ک _{Medial 7-2}	ک _{Medial 8-2}	ک _{Medial 9-2}	ک _{Medial 10-2}
				
ک _{Medial 11-2}	ک _{Medial 12-2}	ک _{Medial 13-2}	ک _{Medial 14-2}	ک _{Medial 15-2}
				
ک _{Medial 16-2}	ک _{Medial 17-2}	ک _{Medial 18-2}	ک _{Medial 19-2}	

<p>ک → ک_{Medial1-2} / <NS>⁺ ___ Final <NS>⁺ ___ ل_{Final} <NS>⁺ ___ لا_{Final} <NS>⁺ ___ <ل><NS>*<All></p> <p>ک → ک_{Medial2-2} / <NS>⁺ ___ ب_{Final1} <NS>⁺ ___ ب_{Final2}</p> <p>ک → ک_{Medial3-2} / <NS>⁺ ___ ج_{Final} <NS>⁺ ___ <ج><NS>*<All></p> <p>ک → ک_{Medial5-2} / <NS>⁺ ___ ر_{Final1} ک → ک_{Medial6-2} / <NS>⁺ ___ س_{Final1}</p>	<p>ک → ک_{Medial10-2} / <NS>⁺ ___ ع_{Final} <NS>⁺ ___ <ع><NS>*<All></p> <p>ک → ک_{Medial11-2} / <NS>⁺ ___ ف_{Final} <NS>⁺ ___ <ف><NS>*<All></p> <p>ک → ک_{Medial12-2} / <NS>⁺ ___ </p> <p>ک → ک_{Medial13-2} / <NS>⁺ ___ م_{Final1} <NS>⁺ ___ <م><NS>*<All></p> <p>ک → ک_{Medial14-2} / <NS>⁺ ___ ن_{Final}</p> <p>ک → ک_{Medial15-2} / <NS>⁺ ___ ه_{Final1} ک → ک_{Medial16-2} / <NS>⁺ ___ ه_{Final}</p>
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<p> <NS>+ ___ <س><NS>*<All> ک → ک Medial7-2 / <NS>+ ___ س Final2 ک → ک Medial8-2 / <NS>+ ___ ص Final <NS>+ ___ <ص><NS>*<All> ک → ک Medial9-2 / <NS>+ ___ ط Final <NS>+ ___ <ط><NS>*<All> <NS>+ ___ <ک> ل Final <NS>+ ___ <ک><ل><NS>*<All></p>	<p> <NS>+ ___ <و><NS>*<All> <NS>+ ___ <ھ><NS>*<All> ک → ک Medial17-2 / <NS>+ ___ ی Final1 ک → ک Medial18-2 / <NS>+ ___ ے Final1 ک → ک Medial19-2 / <NS>+ ___ <Ashort> <NS>+ ___ ة Final <NS>+ ___ <ک><All-lam> <NS>+ ___ <ک><NS-lam> <NS>*<All></p>
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4.5.2 Alternative Medial Meem



<p>م → م Medial1-2 / <NS>+ <Char Before AlternativeMeem> ___ <A> <NS>+ <Char Before AlternativeMeem> ___ <ک><All-lam> <NS>+ <Char Before AlternativeMeem> ___ <ک><NS-lam> <NS>*<All> <NS>+ <Char Before AlternativeMeem> ___ <ل><NS>*<All> <NS>+ <Char Before AlternativeMeem> ___ ب Medial1 <NS>*<All></p>

5. Specialized Analysis of Nastalique

Rules of composing are defined by calligraphy. Calligraphic style exhibits special features in Nastalique. In this setion we disscuss in detail these special features. In Nastalique, each character may have different diacritics associated with it. This is in addition to the main ligature in which characters are joined such that the whole ligature is along a diagonal line. Thus specialized analysis of Nastalique includes analyses of:

- Base line Shifting
- Proportional Spacing
- Nuqta Analysis
- Aerabs Analysis

5.1 Base line Shifting

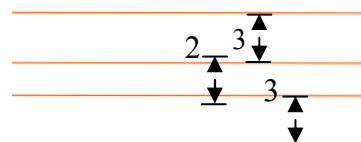
From the point of view of Nastalique text, when it is being written or composed, by addition of one letter at a time, it is the final letter (i.e. the one just added) that has any relation to the baseline. Thus, it is possible by addition of the current letter that the previous ones will be shifted upward or downward depending on the relation of the current letter to the baseline. This is termed as Baseline Shifting.

For baseline, the term Kursi is used in Nastalique. 'Kursi' is defined by four lines. Starting from top to bottom this document refers to them as line 1, line 2, line 3 and line 4 respectively.

Distance between line 1 and line 2 is three 'qat'.

Distance between line 2 and line 3 is two 'qat'.

Distance between line 3 and line 4 is three 'qat'.



Some general rules concerning baseline and baseline shifting are as follows:

- The baseline or Kursi in Nastalique is composed of Four lines, numbered from top to bottom as 1, 2, 3 and 4.
- Of these four, the two lines: 3 and 4 are mainly used. The other two are used infrequently used.
- Most of the letter shapes rest on 3rd or 4th baseline. The resting on a baseline means that they touch it and extend down it a little.
- The Daera's or circular arcs rest on the 4th baseline while the Pointed-Ends rest on the 3rd.
- The 1st line is there to give the reference points to start the Kashish.
- The 2nd line is there to end the Kashish or place the head of Suad.

The general rule in baseline shifting is that the final character shape in the ligature has to be placed on some appropriate line while the preceding character shapes are treated as if they have no baseline. These are only in relation to the final character and one another.

There are the following classes of characters with respect to baseline position:

Daera's {ج، چ، ح، خ، س، ش، ص، ض، ع، غ، ل، ق، ن، ی}

These rest on the 4th line.

Madd's {ب، پ، ت، ث، ف، ک، گ، ے}

These rest on the 3rd line.

Ascendars {ا}

These rest on the 3rd line.

Pointed-Ends {و، ظ، ط، ژ، ز، ر، ر، ر، د، د}

These rest on the 3rd line.

Kashish { ش، س، any join extended in Kashish-like manner}
Starts from 1st and rests below 2nd line.

Meem {م}
Head of Meem rests on 3rd line.

LongRay {ر}
Rests on the 4th line. It is of two types. When LongRay comes at the end of a 3-character ligature, its length is longer and it rest on the 4th line. However, when it comes at the end of a 2-character ligature, its length is somewhat shortened and it just touches the 4th line.

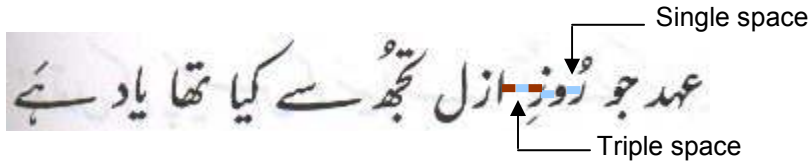
5.2 Proportional Spacing

The major rule in Nastalique for proportional spacing is that “space (distance) between words and within word is always equal” for the whole ‘tehrir’ (text). A paragraph of ‘tehrir’ or written text is always equally spaced; this ‘equal’ space can be used beyond a paragraph. In ideal scenario every page of a book should be written with same space between words. The phrase above is simple in words but complex in meaning. Following are few major reasons for this complexity when dealing with proportional spacing in Nastalique:

- The “equal” distances are not always measured horizontally (see white lines in Urdu text below).
- Also this equal distance can be measured with ligatures, isolated characters and even diacritics (like the comma and letter goal hay’s hook in example below).
- In addition, these spaces are not actually “equal” in all cases; the red lines below indicate extended space between ligatures. In all of the three cases shown below (by red lines) it seems that extended distance is increased due to placement of diacritics.
- Further, distance can be measured from different points of a single glyph depending on context. See circled portion of glyph RayFinal1 glyph below.
- Lastly, on many occasions (especially poetic verses) justification dictates proportional spacing between ligatures and words. However, since justification is out of the scope of this paper such cases of proportional spacing have not been discussed.



Above text also shows that inter word and intra word spaces are equal. In general there are two variations possible in proportional spacing. Firstly, the spaces between words are same as those between ligatures (as given above). Secondly, spaces between words are approximately three times the intra word spaces.

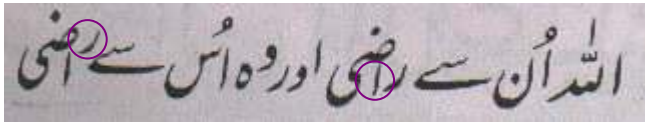


Former case with equal spaces was preferred when a major emphasis was on writing maximum number words in a single line so that eventually there are lesser number of pages to compose and therefore lesser cost of publishing. Since this constraint is absent these days, it is preferred to write words well separated from each other. However, further discussion in this section is limited to the case where inter and intra word spaces are same as tripled inter word spacing can be achieved by simply tripling this inter word spacing.

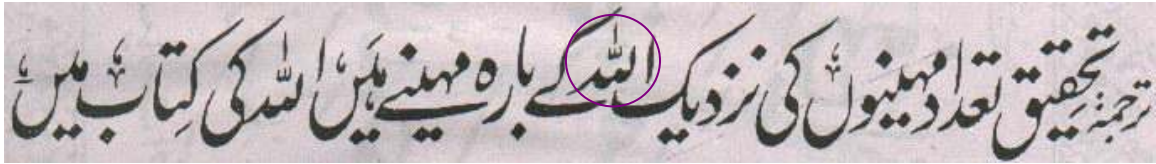
5.2.1 Categorization of Nastalique with respect to Proportional Spacing:

In order to distinguish between different ways through which complex proportional spacing is achieved in Nastalique, Nastalique may be categorized as **complex** and **simple**. The **complex** form may involve base line shifting (or overlapping ligatures and words). While in **simple** Nastalique, words are written in their respected positions as dictated by Nastalique's 'kursi'. To precisely define the border line between complex and simple Nastalique, consider the following ways through which directly or indirectly proportional spacing is achieved in Nastalique.

1. Base line shifting: To squeeze in more words, a single ligatures or isolated characters can be placed over other text. In example encircled *ray* is placed above its base position while encircled *alif* is placed below its default position at line 3 of *kursi*.



Following is another example in which a whole word *Allah* is placed over other words.



2. Overlapping onto previous ligatures: Spaces can be reduced by overlapping ligature onto previously written characters or ligatures. Notice the word *pa-kiza* and *ba-tan* in the example below.



3. Overlapping onto following ligatures: Similarly spaces can be condensed by overlapping characters on next character or ligature. A special case in this regard is filling empty space created by letter *bari yeh*'s stroke. This empty space can be filled by an isolated character (case i), whole ligature (case ii) or a combination of both (case iii). //Arabic translation , try qalm size same



4. Writing characters after main ligature: Isolated characters *alif*, *dal*, *ray*, *wao* and *goal hay* are smaller in size and can be written after whole line of the main text has been written. In this case placement of these characters is unpredictable and is left on calligrapher's own choice. The letter *alif* encircled below has been written after the main text.



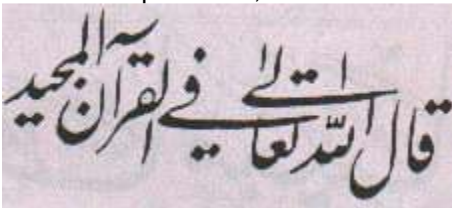
5. Using diacritics to balance space: Some ligatures leave a chunk of empty spaces in normal text. Calligraphers mostly fill this space by nuqtas and other diacritics including comma symbols to proportionally place these ligatures in otherwise compress text. Encircled portion below shows how nuqta and other diacritic like *hamza* indicator and *pesh erab* (vowel indicator) are used to fill spaces.



6. Combination of above features: Many artistic versions of Nastalique can be formed by merging ligatures and combining the features discussed above. Below are two such artistic pieces of Nastalique writing. It can be seen how merging, overlapping, base line shifting and nuqta placement are used to create the balance text below. //space constraint



In the example below, notice that there is no horizontal line on which the text has been written.



5.2.2 Discussion

A view of simple or plain Nastalique can be seen when whole books are composed by calligraphers in this writing style. In text written in these books features discussed above are largely absent. Last three ways of balancing text discussed above are approximately never used in plain Nastalique. The other three features (base line shifting and overlapping ligatures) are written in plain text only when the word or ligature occurs at the end of a line. Even in this case, these

features are triggered when calligrapher tries to leave no blank space at end of line and squeezes the last ligature or word to fill and eventually justify this line with respect to other lines written.

Redefining Simple and Complex Nastalique: It can be said that if justification is ignored then simple or plain Nastalique consists of series of characters and ligatures placed in their original *kursi* position. Every other variation of simple Nastalique can be termed as complex Nastalique. Further down we limit our discussion to simple or plain Nastalique. A sample of simple Nastalique is given below.



5.2.3 Calligrapher's intuition

Interestingly in simple Nastalique, calligraphers write proportionally spaced balance text without conscious knowledge of or ability to explain the principles they are following. However, after writing a sequence of words and then measuring distances, spaces are found to be same and text balanced. It seems that by rigorous practice calligraphers are able to incorporate proportional spacing within writing. In effect, after writing a ligature or character, placement of pen to write first stroke of next ligature actually implements proportional spacing.

Before writing a ligature (the term ligature here refers to both ligatures and isolated characters) calligrapher perceives the image of that ligature. The vertical placement of pen is due to the perceived height of that image. While the horizontal placement of pen is determined by how closely this perceived image can be placed to previously written text such that the two do not merge and a reasonable space is left in between. This reasonable distance constitutes the "equal distance" discussed above and is measured considering the present and previous ligature.

Moreover a calligrapher's perceived image mostly do not consider 'nuqtas' and other diacritics. From this it can be inferred that in general proportional spacing precedes nuqta placement in writing Nastalique. In summary, proportional spacing is adjustment of reasonable space between two ligatures of which nuqtas of second ligature is mostly not considered. Concept of reasonable space is explained next.

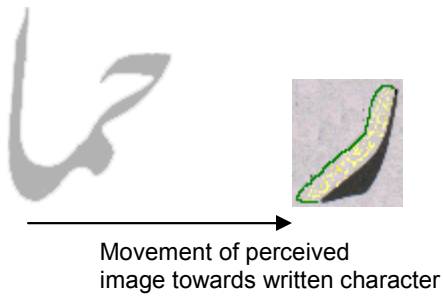
How proportional spacing is achieved: Every ligature that has been written consists of equidistant region or locus around it. When next ligature is being placed, the perceived image (to be written) is shifted or moved towards the previous ligature until it comes in contact with some part of the equidistant region around that ligature. Consider the word *ray*.



After it has been written, the equidistant region around it is shown below as yellow dots with green boundary.



Now the next ligature or perceived image is placed such that it touches the region boundary given in green of previous character.

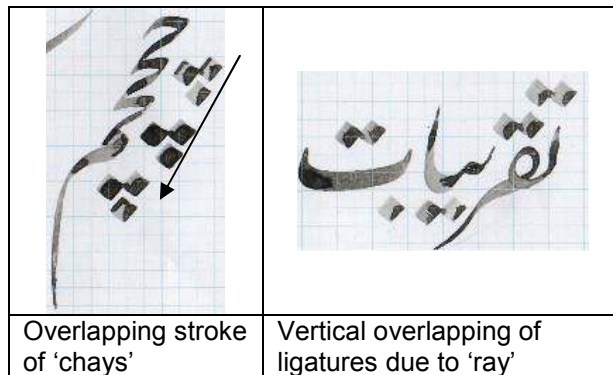


So the outcome is proportionally spaced ligatures and characters.



5.3 Nuqta Analysis

Formation of ligatures and proportional spacing dictate placement of nuqtas in Nastalique. In this writing style ligatures have overlapping as well as diagonal strokes. Also, proportional spacing even in simple Nastalique produces vertically overlapping ligatures. Due to proportional spacing letter 'ray' usually results in overlapping ligatures. While 'jeem' class letters in most cases gives overlapping strokes. Both these examples are given below.











Due to these features Nuqta placement in Nastalique is complex and even fuzzy. As a rule nuqtas are placed parallel to the slant of the ligature. Effort is also made to place a nuqta as close to its corresponding character glyph as possible; while maintaining a reasonable space between itself and surrounding ligatures and other diacritics already placed.

5.3.1 Types of Nuqtas

All diacritical marks that are integral part of a word and help in distinguishing between words are all grouped together under the terminology "Nuqtas". The list below excludes aerabs which are placed after nuqtas and are discussed in section 5.4.

Nuqtas	Glyph of Nuqta	Qat Size Ratio	Characters
Single dot	◆	One	ف غ ظ ض ظ ض ز ذ خ ج ب

Double dots		One	ی ت ق
Triple dots below		One	پ چ
Triple dots above		One	ث ش ژ
Small Tuay		Half	ٹ ڈ
Hay Hook big		One	ہا
Hay Hook small		Half	Initial and Medial Goal Hay
Madd		One	آ
Hamza		Half	Initial Hamza

5.3.2 Classification with respect to Position

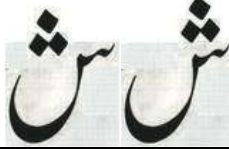


The nuqtas defined above can be grouped together according to their vertical position in a ligature. Nuqtas can occur below or above as given below. The letters between arrow brackets (<>) as mentioned below have same base glyph shape but differ in type of nuqtas. This classification corresponds to the one given in section 2.2.

Nuqtas Below: < ہ پ ی > < ج چ > < ہ >

Nuqtas Above: < ف ق > < غ ظ ض ش > < ژ ز > < ڈ ذ > < خ > < ٹ ث ن ء >

5.3.3 Placement of Nuqtas in Mufridaats

For mufridaats, nuqtas are usually not displaced. Exceptions to this are characters ش ق ف, which allow different positions for nuqtas placement. The reason behind this shifting can be collision or visual balance of letter. This displacement is shown below.

		
Sheen	Fay	Qaf

5.3.4 Placement of Nuqtas in ligatures

Many new considerations are introduced for placing nuqtas in ligatures. Composition of ligature and placement of neighboring nuqtas are common context dependency for placement of a particular nuqta. At times neighboring ligatures also effect placement of nuqtas in another ligature. In such a case exceptional shift in placement of nuqtas can occur. Thus many factors effect placement of nuqtas. Some major factors are discussed in next.

5.3.5 Factors effecting Nuqta placement

Factors effecting nuqta placement have been classified as internal and external. Internal factors are factors in which placement of a nuqta in a ligature is influenced by characters and diacritics of that ligature alone. While in external, factors external to the base ligature of that nuqta comes into play.

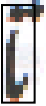
Internal factors

1. Consideration of horizontal boundary of ligatures in text:

The Nuqta(s) must be placed such that there is a minimum extension of Nuqtas beyond the ligature boundary. This is achieved by shifting them both vertically and horizontally along the ligature as much as possible. This can be illustrated in the example below. Consider the word *ta* (*Tay* + *alif*). If the nuqtas were placed at their default point, they would extend too much outside their ligature boundary.



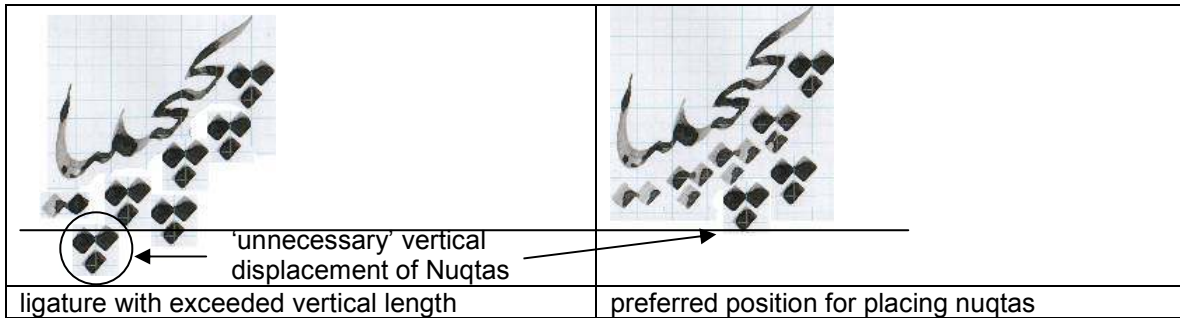
Thus there is a need to shift nuqtas. Since due to *alif* no immediate horizontal shift is possible so they are first moved vertically upward and then to the left as shown below:



Note that they still extend beyond the ligature, but now the extension is minimal.

2 Consideration of vertical space

Like horizontal shift, the 'unnecessary' vertical displacement of nuqtas is also avoided. This is illustrated below.



3. Order of reading nuqtas within ligature

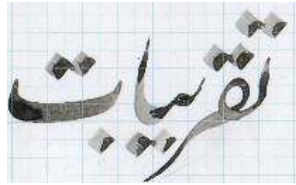
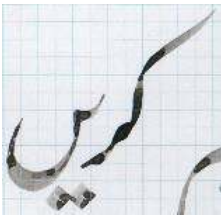
No matter where the nuqtas are displaced, the order by which the nuqtas are read is maintained. It is from right to left for nuqtas placed above. For the ones placed below, it is dependent on levels or height. That is for a particular level, nuqtas are read from right to left. Once this level is complete, then the next level is parsed. In the example below order of writing of ligature from right to left is: *ی پ چ ی چ ی پ* and reading order is obtained as discussed above.



External factors

1. Consideration of proportional Spacing


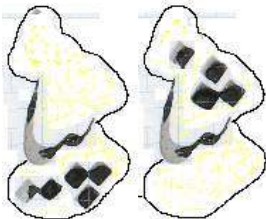
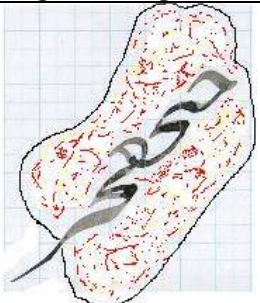

As discussed before (section 5.2) a calligrapher does not consider 'nuqtas' and other diacritics when placing the next ligature. For this reason in general proportional spacing precedes nuqta placement in writing Nastalique. The following examples shows shift in position of nuqtas to avoid collision with other ligatures or nuqtas so as to maintain proportional spacing.

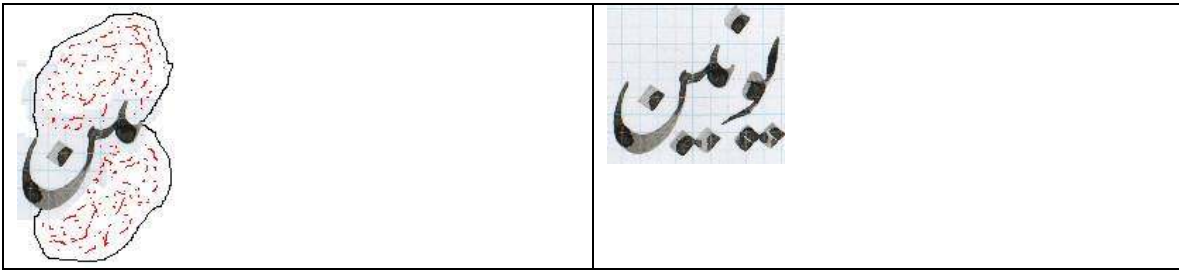


Lower displacement is usually due to letters like ray which moves next coming lower nuqtas. Similarly letter 'kaf' easily displaces above nuqtas of previous character.

5.3.6 Region around ligatures

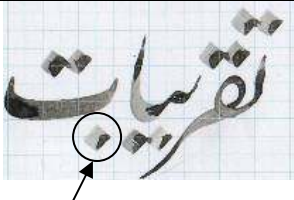

As it can be seen from discussion above, there is no defined point or rule for placing nuqtas in a ligature. However, there is a small area around ligatures in which its nuqtas can be placed. This region is usually controlled by the horizontal boundary of a ligature, but there are exceptions such as discussed below.

<p>Region for ligature with final alif</p> 	<p>Example: Piya and sana</p> 
<p>Region for ligature with final Ray2</p> 	<p>Example</p> 
<p>Region for ligature with daeras</p>	<p>Example: Union</p>



Exceptional cases:

In exceptional cases, nuqtas can leave the bounded region defined for their ligatures. In almost all such cases displacement of nuqtas far beyond its ligature is done in an effort to maintain proportional spacing. Two examples below show this large shift in nuqta placement. In the first example nuqta of bay violate the bounded region and hence the ligature boundary. While in second example right boundary of ligature has been violated.

Example: Taqribat	Example: Intezar
 <p data-bbox="235 919 743 982">Exceptional placement of Nuqta beyond its ligature</p>	

5.3.7 Order of writing nuqtas within ligature

There is a certain order that is maintained in writing nuqtas on ligature. In general the above nuqtas are placed before the ones placed below, so as to avoid smudging of ink. In both cases nuqtas are usually written from right to left along the slant of the ligature; avoiding same height of two consecutive nuqtas.

In cases where nuqtas require more space than the one generally available along the slant of the ligature, order of writing nuqtas depends on calligrapher's own choice. Further discussion deals with order of writing in such complex cases. The considerations mentioned in 5.3.5 are taken into account when following this order as explained below. Here still the above nuqtas are placed before the ones placed below.

Firstly, the right most nuqta is placed. Remaining nuqtas are so placed such that minimum number of nuqtas are displaced. So a calligrapher intelligently writes nuqtas which may result in irregular writing order. By and large, nuqtas of all classes except bay receive higher preference in retaining their non-disturbed position. While the nuqtas of bay class shifts easily and have lower priority level in order of writing ligatures.

Also, certain effort is made to maintain the final nuqta within the region around the ligature. This is achieved by writing nuqtas from right to left, till a point is reached where if nuqta is placed, it would compel the 'final nuqta' to be placed outside the region around its ligature. At this point final nuqta is placed then remaining nuqtas are placed from right to left.

5.3.8 Madd Analysis

The 'Madd' diacritic is always placed above letter 'alif'. However, it can be easily displaced since it is placed after all other nuqtas discussed in 5.3.1. Frequently it is displaced towards right or height is further increased. This can be seen from two examples below.



Depending on context 'madd' can also move towards left but such cases are rare. Even in these cases displacement is usually dictated more by visual balance than by diacritic placement. When surrounding ligatures or above nuqtas of next ligature comes in close vicinity of 'madd', 'madd' is displaced. If however isolated ش or ق follow alif-madd-aa (letter 'alif' with diacritic 'madd') then diacritic 'madd' is not displaced, and the nuqtas of these characters are displaced.

5.3.9 Hook Analysis

Urdu alphabet 'goal hay' has a diacritic 'hook' associated with it when it comes at initial or medial position of a ligature. Letter 'goal hay' varies in its form and shape depending on its position in a ligature. It has entirely different form for all the four positions: isolated, initial, medial and final position. Following table shows five major shapes of 'goal hay' (other shapes mentioned in section 4 are variations of these shapes). It may be noticed that letter 'goal hay' in its initial position has two different main shapes.

o _{isolated}	o ₁	o ₇	o _{Medial7}	o _{Final1}

Of these different shapes of 'goal hay' diacritic hook is placed underneath initial goal hay (o₁ and o₇) only. In some text this diacritic is also placed below medial goal hay, however this practice is not very common among calligraphers. Since the shape of medial goal hay is unique enough to indicate the reader of its presence. This can be seen from the phrase below:



Missing diacritic 'hook'

As mentioned in section 4.2.11, with the exception of hook occurring in ligature 'ha' (Goal-Hay + Alif); all other hooks are written with another pen whose 'qat' size is half the qat size of pen with which base ligature is written. Ligature 'ha' is written with the same pen as the base ligature itself. When writing diacritics 'hook' diacritic is placed last. However, priority of writing hook in ligature 'ha' is highest among diacritics but lower than proportional spacing as given in arbitrary word below.



All 'hooks' are placed at a distance from its base ligature except ligature 'hey' (letter 'goal hay' + Bari yeh) in which the hook is attach with the ligature stroke as shown below.



5.4 Aerabs Analysis

Aerabs represents is a class of diacritics which are mainly used for pronunciation. These aerabs can be placed on any letter of a word but with the exception of 'shad' no two aerabs are placed on a single letter. In Urdu script aerab diacritics are not usually written on all characters of a word but are assumed to be present and are always read. Aerabs are usually only inserted into text whenever the writer wishes to introduce a particular pronunciation of a character. In Urdu, the presence of 'kasr-e-izafat' (aerab 'zair') in compound words is usually indicated and is therefore mostly written.

5.4.1 Types of Aerabs

Following table shows different type of aerabs as used in Urdu text.

Aerabs	Glyph of Aerab	Placement with respect to ligature	Aerab Qat Ratio w.r.t ligature
Zabar	ا	Above	Half
Zair	ا	Below	Half
Pesh	و	Above	Half
Tashdid	و	Above	Half
Jazm	و	Above	Half
Khari zabar	ا	Above	Three fourth
Khari zair	ا	Below	Three fourth
Do zabar	ا	Above	Half
Do zair	ا	Below	Half
Do pesh	و	Above	Half
Ulti pesh	و	Above	Half
Noon Gunnah Symbol	و	Above	Half

5.4.2 Placement of Aerabs

Since these diacritics are associated with sounds, it is always preferred to write these diacritics within the vicinity of their orthographic representation. Aerabs are placed on or below letter 'meem' and 'dal' in the following examples.



Aerabs may be shifted due to clashes with nuqtas



Original position of zair
Shift of aerab due to nuqtas

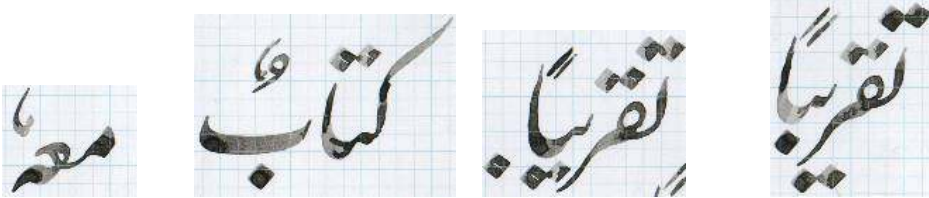
Aerabs can also be placed to balance space of its corresponding orthographic representation. Following example highlights these features.



aerab placed in centre of glyph for letter 'sheen'

When an aerab is placed on aspirated or breathy sounds, it is placed on the first character and not on letter 'do chashmi hay' which follows it. It may be noted that letter 'do chashmi hay' is a necessary but not a sufficient condition to indicate aspiration or breathiness of a sound.

Placement of above aerabs: Aerabs 'pesh', 'tashdid', 'jazm', 'do zabar', 'do pesh' and 'Ulti pesh' are all placed on the same position as that of aerab 'zabar'.



When 'zabar' is to be placed over a character with above nuqtas it is positioned as shown below.



Position of aerab 'zabar' over glyphs is along the slant of the ligature. This is different from other writing styles like 'Naskh' where aerabs are placed on a horizontal line above the ligature. In case of overlapping letters in a ligature aerabs are usually ignored.

Placement of 'zair': 'Zair' is usually placed in parallel with glyph or its corresponding nuqtas with which it is associated. For this reason its diagonal tilt may vary and can be different from that of 'zabar'. Relation of 'zair' with nuqtas and characters is shown below.

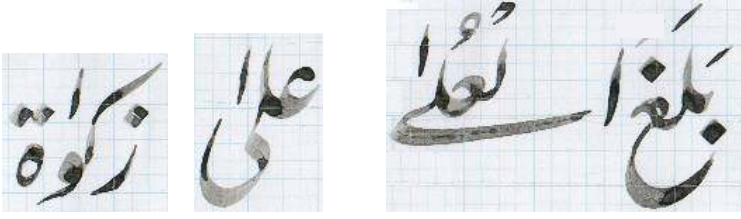


Some calligraphers wish to maintain a single slant for aerabs 'zabar' and 'zair', where zair is a duplicated version of 'zabar'. This version of 'zair' can be seen below.



Placement of Kari zabr:

Aerab 'Khari zabar' is usually placed after the character it represents. However, if 'khari zabar' is placed on letter 'alif' it is placed to its right. In Urdu words, this aerab is mostly placed for letters that are followed by 'choti yeh', 'bari yeh' and 'wao'. When Arabic words are written in Nastalique there is no such restriction. It is placed above the letter it represents. Consider the examples below:



Placement of Kari zair and 'do zair': The usage of 'do zair' is limited to last letter of the word only. It is placed towards the end of the last letter of the ligature as shown below.



'Khari zair' is usually written below letter 'goal hay'. Following example illustrates its placement.



5.4.3 Placement of Khadi Zabar and Khadi Zair

Since these two aerabs are vertical, they are placed so as to reduce vertical space. The examples below show that Khadi Zabar is placed on the right connector of letter to which it belongs.











5.5 Modified Approach to Proportional Spacing and Nuqta Placement

Here are some observations regarding the above-mentioned analyses. The points below cater for a goodly level of nuqta placement and proportional spacing. It is more than probable that exceptions will be found in writing of calligraphers. However, the points below give an initial model that caters to most of the cases.

1. The nuqta placement should be resolved first and then the proportional spacing should take into account the ligatures inclusive of their nuqtas.
2. The nuqta placement should be considered in the reverse order of writing.
3. The nuqta shifting is in the reverse order of writing.
4. The nuqta shifting is only necessary in cases where the overlap of different forms is significant enough to bring about a clash.
5. Due to above reason, the nuqta placement issues should be studied in connection with the possible forms of characters and their combinations.
6. It is very seldom that a character or nuqta collision takes place at the depth of more than two.

7. Due to reason above, it is practicable to attack the problem of the nuqta placement by studying degree of overlap in two-character combinations. This will remove most of the collisions.
8. The nuqtas of the final characters are not affected.
9. The nuqtas of Daera's are not affected.
10. The nuqta's of final Bay are not affected.
11. The shifting of nuqtas should be in accordance with the degree of overlap.
12. The degree of overlap mentioned above is that of the character shapes or glyphs, of which we already have a fairly complete database.
13. The glyphs are divided into four categories according to the degree of overlap as explained below
 - a. Overlap < 25% No Shifting
 - b. 25% < Overlap < 50% Shift Nuqtas backwards by 50% of glyph width
 - c. 50% < Overlap < 75% Shift Nuqtas backwards by 75% of glyph width
 - d. Overlap > 75% Shift Nuqtas backwards by 100% of glyph width
14. The shifting of the nuqtas is cumulative.
15. The following example illustrates these principles at work:

Characters	Chay Chay Meem Chay Aray	
Character Shapes		
Categories	Each of these character shapes falls into the fourth category, where the overlap is more than 75%. Hence starting from the last letter backwards, the nuqtas will have to be shifted approximately 75% of ligature width each time.	
Composed Ligature without nuqtas		
Composed ligature without nuqta shifting	Note collision of the nuqtas of second chay with both the nuqtas of the first chay and the third letter meem.	

Composed ligature with nuqta shifting	Last Letter = Aray – Nuqta is above 2 nd Last Letter = Chay –Nuqta is below Therefore no clash and no adjustment necessary.	
	2 nd Last Letter = Chay – Nuqta is below 3 rd Last Letter = Meem – No nuqta Therefore no adjustment necessary.	
	3 rd Last Letter = Meem 4 th Last Letter = Chay Overlap degree = 4 Adjust Chay's nuqtas by sifting them 75% backwards.	
	4 th Last Letter = Chay 5 th Letter = Chay Overlap degree = 4 Adjust Chay's nuqtas by sifting them 75% backwards. The previous adjustment of 75% will be added to it to make its shifting 150%.	

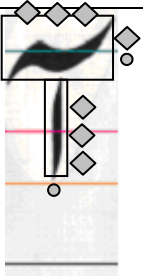
16. The algorithm shown above based on the principles mentioned as points 1-14 can not be directly applied to the classes and grammar approach of the logical model. However, it can be adapted to it. The categories of overlap will dictate new classes.
17. The physical implementation of this algorithm may or may not be possible/feasible in OTF technology. Research into this issue remains to be conducted as yet.
18. It would perhaps be better to combine a vertical shift with the horizontal one to the nuqtas in case of adjustment. However, work on this also remains to be done.

Appendix:

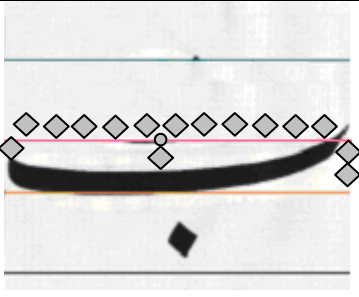
Appendix A: Template for Mufridaats

The following section illustrates the measurements and position of mufridaat as they are *written in Takhti*. Please note that the positioning of letters in takhti or tablet is different from the one when written in text or *tehrir*.


Details for Glyph Alif Mad

Name of Glyph	Alif Mad	
Tablet (Takhti)	mufridaat	
Form (initial, medial, Final and isolated)	Isolated	
Sub parts	2	
Relation to 'Kursi'	Rests on line 3	
Measurement	As in Figure	
Notes: First part is called mad'da and second part is alif.		

Details for Glyph Bay

Name of Glyph	Bay	
Tablet (Takhti)	mufridaat	
Form (initial, medial, Final and isolated)	Isolated	
Sub parts	null	
Relation to 'Kursi'	On line 3	
Measurement	As in Figure	
Notes: Horizontal measurement can vary from 9 to 11 qat.		

Details for Glyph Tey

Name of Glyph	Tey	
Tablet (Takhti)	mufridaat	
Form (initial, medial, Final and isolated)	Isolated	
Sub parts	null	
Relation to 'Kursi'	On line 2	
Measurement	As in Figure	
Notes: Left nuqta is a curved (khamdar) while the other is straight by definition. However they can vary in practise.		

Details for Glyph Jeem

Name of Glyph	Jeem	
Tablet (Takhti)	mufridaat	
Form (initial, medial, Final and isolated)	Isolated	
Sub parts	3	
Relation to 'Kursi'	line 2,3,4	
Measurement	As in Figure	
Notes: The daman rests on line 4.		

Details for Glyph Dal 1

Name of Glyph	Dal 1	
Tablet (Takhti)	mufridaat	
Form (initial, medial, Final and isolated)	Isolated	
Sub parts	2	
Relation to 'Kursi'	line 2,3	
Measurement	As in Figure	
Notes: The two daals are very similar to each other. However calligraphers mentioned the difference in curvature.		

Details for Glyph Rey Lati

Name of Glyph	Rey Lati	
Tablet (Takhti)	mufridaat	
Form (initial, medial, Final and isolated)	Isolated	
Sub parts	null	
Relation to 'Kursi'	line 2,3	
Measurement	As in Figure	
Notes: It's head is slightly tilted towards right.		

Details for Glyph Dal 2

Name of Glyph	Dal 2	
Tablet (Takhti)	mufridaat	
Form (initial, medial, Final and isolated)	Isolated	
Sub parts	2	
Relation to 'Kursi'	line 2,3	
Measurement	As in Figure	
Notes: Its head is similar to shape used in ligatures like bay-chotiyeh		

Details for Glyph Rey Ghari

Name of Glyph	Rey Ghari	
Tablet (Takhti)	mufridaat	
Form (initial, medial, Final and isolated)	Isolated	
Sub parts	null	
Relation to 'Kursi'	line 2,3	
Measurement	As in Figure	
Notes: It's head is longer and straighter than rey lati.		


Details for Glyph Seen

Name of Glyph	Seen	
Tablet (Takhti)	mufridaat	
Form (initial, medial, Final and isolated)	Isolated	
Sub parts	3	
Relation to 'Kursi'	line 2,3,4	
Measurement	As in Figure	
Notes: Daera rests on line 4.		


Details for Glyph Sheen

Name of Glyph	Sheen	
Tablet (Takhti)	mufridaat	
Form (initial, medial, Final and isolated)	Isolated	
Sub parts	2	
Relation to 'Kursi'	line 2,3,4	
Measurement	As in Figure	
Notes: Kashish can vary from 9 to 11 qat. In takhti distance between daeras of seen and sheen is 3 - 3 1/2 qat.		


Details for Glyph Suad

Name of Glyph	Suad	
Tablet (Takhti)	mufridaat	
Form (initial, medial, Final and isolated)	Isolated	
Sub parts	3	
Relation to 'Kursi'	line 2,3,4	
Measurement	As in Figure	
Notes: First part may be called suad head and is used in other shapes as well. Daera rests on line 4 and is similar to that of seen.		

Details for Glyph Toay

Name of Glyph	Toay	
Tablet (Takhti)	mufridaat	
Form (initial, medial, Final and isolated)	Isolated	
Sub parts	3	
Relation to 'Kursi'	line 1, 2 (difference in Takhti and text)	
Measurement	As in Figure	
Notes: First part is similar to alif, second is like suad head while third is rey lati.		

Details for Glyph Ain

Name of Glyph	Ain	
Tablet (Takhti)	mufridaat	
Form (initial, medial, Final and isolated)	Isolated	
Sub parts	2	
Relation to 'Kursi'	line 2,3,4	
Measurement	As in Figure	
Notes: First part is like isolated hamza and daman is similar to that of jeem.		

Details for Glyph Fay

Name of Glyph	Fay	
Tablet (Takhti)	mufridaat	
Form (initial, medial, Final and isolated)	Isolated	
Sub parts	2	
Relation to 'Kursi'	On line 1	
Measurement	As in Figure	
Notes: First part may be called fay head and is used in other shapes as well. Second part is like tey.		

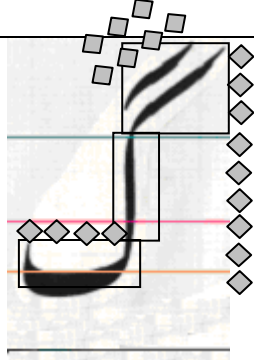
Details for Glyph Qaf

Name of Glyph	Qaf	
Tablet (Takhti)	mufridaat	
Form (initial, medial, Final and isolated)	Isolated	
Sub parts	2	
Relation to 'Kursi'	line 3,4	
Measurement	As in Figure	
Notes: First part is that of fay and second is seen's daera.		


Details for Glyph Kaf

Name of Glyph	Kaf	
Tablet (Takhti)	mufridaat	
Form (initial, medial, Final and isolated)	Isolated	
Sub parts	3	
Relation to 'Kursi'	On line 3	
Measurement	As in Figure	
Notes: It is the longest characters. Comprises of alif like shape of 5 qat, tey like base and a digonal stroke.		


Details for Glyph Gaf

Name of Glyph	Gaf	
Tablet (Takhti)	mufridaat	
Form (initial, medial, Final and isolated)	Isolated	
Sub parts	4	
Relation to 'Kursi'	On line 2	
Measurement	As in Figure	
Notes: Similar to kaf.		

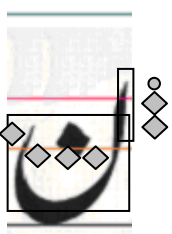
Details for Glyph Laam

Name of Glyph	Laam	
Tablet (Takhti)	mufridaat	
Form (initial, medial, Final and isolated)	Isolated	
Sub parts	2	
Relation to 'Kursi'	line 1,2,3 and 4	
Measurement	As in Figure	
Notes: Daera rests on line 4.		


Details for Glyph Meem

Name of Glyph	Meem	
Tablet (Takhti)	mufridaat	
Form (initial, medial, Final and isolated)	Isolated	
Sub parts	2	
Relation to 'Kursi'	line 2,3,4	
Measurement	As in Figure	
Notes: Extends below line 4.		


Details for Glyph Noon

Name of Glyph	Noon	
Tablet (Takhti)	mufridaat	
Form (initial, medial, Final and isolated)	Isolated	
Sub parts	2	
Relation to 'Kursi'	line 2,3,4	
Measurement	As in Figure	
Notes: Daera rests on line 4.		

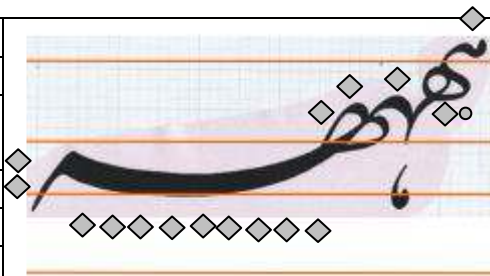
Details for Glyph Wao

Name of Glyph	Wao	
Tablet (Takhti)	mufridaat	
Form (initial, medial, Final and isolated)	Isolated	
Sub parts	2	
Relation to 'Kursi'	line 2	
Measurement	As in Figure	
Notes: First part is that of fay and second is rey lati.		


Details for Glyph Goal Hay

Name of Glyph	Goal Hay	
Tablet (Takhti)	mufridaat	
Form (initial, medial, Final and isolated)	Isolated	
Sub parts	null	
Relation to 'Kursi'	line 2,3	
Measurement	As in Figure	
Notes:		

Details for Glyph Do Chasmi Hay

Name of Glyph	Do Chasmi Hay	
Tablet (Takhti)	mufridaat	
Form (initial, medial, Final and isolated)	Isolated	
Sub parts	null	
Relation to 'Kursi'	line 1,2,3	
Measurement	As in Figure	
Notes:		

Details for Glyph Hamza

Name of Glyph	Hamza	
Tablet (Takhti)	mufridaat	
Form (initial, medial, Final and isolated)	Isolated	
Sub parts	null	
Relation to 'Kursi'	line 1,2	
Measurement	As in Figure	
Notes:		

Details for Glyph Choti Yeh

Name of Glyph	Choti Yeh	
Tablet (Takhti)	mufridaat	
Form (initial, medial, Final and isolated)	Isolated	
Sub parts	2	
Relation to 'Kursi'	line 2,3,4	
Measurement	As in Figure	
Notes: Second portion rests on line 4. This is different from daera of seen.		

Details for Glyph Bari Yeh

Name of Glyph	Bari Yeh	
Tablet (Takhti)	mufridaat	
Form (initial, medial, Final and isolated)	Isolated	
Sub parts	2	
Relation to 'Kursi'	line 1,2	
Measurement	As in Figure	
Notes: Rests on line 2		

Details for Glyph La

Name of Glyph	La	
Tablet (Takhti)	mufridaat	
Form (initial, medial, Final and isolated)	Isolated	
Sub parts	3	
Relation to 'Kursi'	line 1,2	
Measurement	As in Figure	
Notes: First and second part are like alif.		